

465A AMPLIFIER

OPERATING AND SERVICE MANUAL

HEWLETT  PACKARD



CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.



OPERATING AND SERVICE MANUAL

(HP PART NO. 00465-90000)

MODEL 465A AMPLIFIER

SERIALS PREFIXED: 511-

Copyright Hewlett-Packard Company 1965

01775-1

Printed: MARCH 1965

TABLE OF CONTENTS

Section	Page	Section	Page
I GENERAL DESCRIPTION	1-1	V MAINTENANCE	5-1
1-1. Description	1-1	5-1. Introduction	5-1
1-3. Instrument Identification	1-1	5-3. Test Equipment Required	5-1
II INSTALLATION	2-1	5-5. Performance Checks	5-1
2-1. Introduction	2-1	5-7. Accuracy and Gain Check	5-1
2-3. Initial Inspection	2-1	5-8. Frequency Response Check	5-1
2-5. Power Requirements	2-1	5-9. Input Impedance Check	5-2
2-7. Grounding Requirements	2-1	5-10. Output Impedance Check	5-2
2-10. Installation	2-1	5-11. Distortion Check	5-2
2-12. Bench Mounting	2-1	5-12. Noise Check	5-4
2-14. Rack Mounting	2-1	5-13. Adjustment and Calibration Procedures	5-4
2-16. Combination Mounting	2-1	5-15. Power Supply Adjust (+45 V)	5-4
III OPERATING INSTRUCTIONS	3-1	5-16. Bias Adjust (R15)	5-4
3-1. General	3-1	5-17. 1 MC Adjust (C5)	5-4
3-3. Description of Controls	3-1	5-18. Servicing Etched Circuit Board	5-4
IV THEORY OF OPERATION	4-1	5-21. Troubleshooting Technique	5-5
4-1. Introduction	4-1		
4-3. General Circuit Description	4-1		
4-5. Detailed Circuit Description	4-1		
4-7. First Amplification Stage	4-1		
4-9. Second Amplification Stage	4-1		
4-11. Output Circuitry	4-1		
4-13. Feedback Circuitry	4-1		
4-15. Regulated Power Supply	4-1		
VI REPLACEABLE PARTS	6-1		
6-1. Introduction	6-1		
6-4. Ordering Information	6-1		
6-6. Non-Listed Parts	6-1		
APPENDIX			
A CODE LIST OF MANUFACTURERS			
B SALES AND SERVICE OFFICES			

LIST OF TABLES

Number	Page	Number	Page
1-1. Specifications	1-0	5-4. Front Panel Troubleshooting	5-5
5-1. Test Equipment Required	5-0	5-5. Troubleshooting	5-6
5-2. Frequency Response Test	5-2	6-1. Reference Designation Index	6-2
5-3. Distortion Check	5-3	6-2. Replaceable Parts	6-5

LIST OF ILLUSTRATIONS

Number	Page	Number	Page
1-1. Hewlett-Packard Model 465A Amplifier . .	1-0	5-2. Distortion Check	5-3
3-1. Front and Rear Panel Controls, Indicators and Connectors	3-0	5-3. Shielded Load for Residual Noise Check .	5-4
4-1. Model 465A Amplifier Block Diagram . .	4-0	5-4. Troubleshooting Tree	5-6
5-1. Frequency Response Check	5-1	5-5. Top View	5-7
		5-6. Printed Circuit Board, Parts Location . .	5-8
		5-7. Amplifier Schematic	5-9/5-10

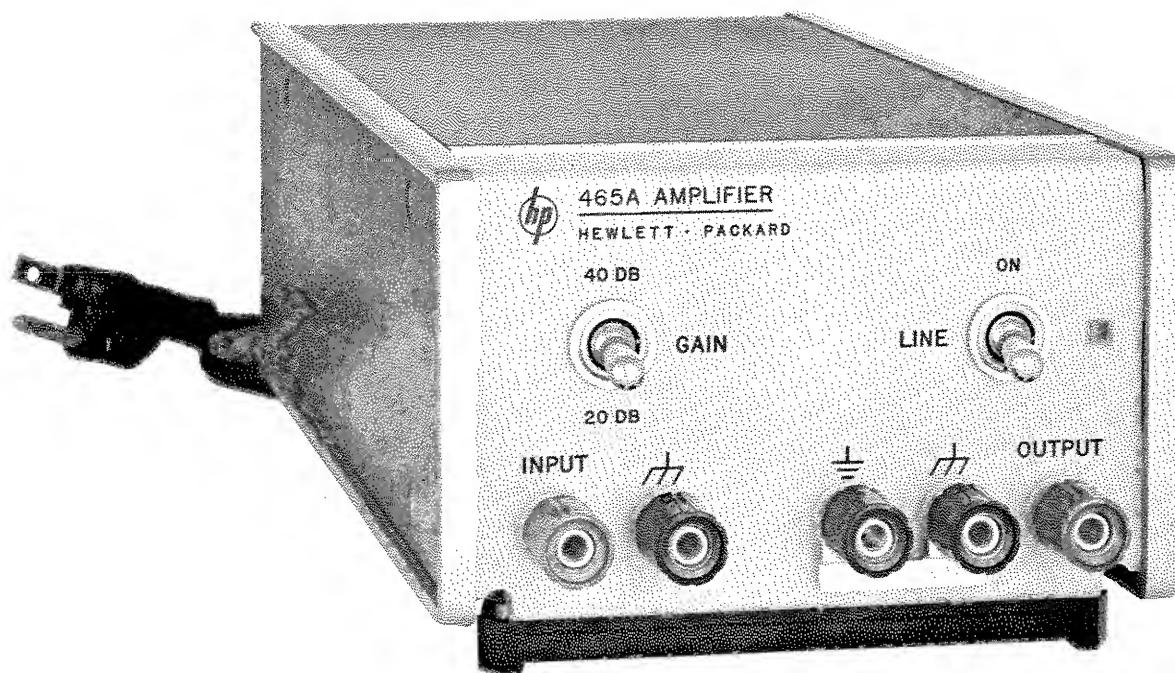


Figure 1-1. Hewlett-Packard Model 465A Amplifier

Table 1-1. Specifications

Voltage Gain: 20 db (X10) or 40 db(X100), open circuit.	Distortion: 1%, 5 cps to 100 kc; 2%, 100 kc to 1 Mc.
Gain Accuracy: ± 0.1 db ($\pm 1\%$) at 1000 cps.	Input Impedance: 10 megohms shunted by < 20 pf.
Frequency Response: ± 0.1 db, 100 cps to 50 kc; less than 2 db down, 5 cps to 1 Mc.	Output Impedance: 50 ohms
Output: greater than 5 volts rms into 50 ohms (1/2 watt); greater than 10 volts rms open circuit.	Noise: not greater than 25 μ v rms referred to input (with 1 megohm across input). Weight: 3 lbs, 12 oz.

SCOPE

This manual contains the information necessary for operating and servicing the standard Model 465A Amplifier and the Model 465A/Option 01 Amplifier (rear input connectors in parallel with front panel connectors).

SECTION I GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The -hp- Model 465A is a general-purpose amplifier, and an ideal impedance converter (10 meg-ohms to 50 ohms). This amplifier has extremely stable 20 db or 40 db gain over a continuous frequency range of 5 cps to 1 megacycle. Either gain may be selected quickly with a switch on the front panel. The output stage provides low output impedance and wide dynamic range. The -hp- 465A is a three-terminal device isolated from chassis and may be floated up to 500 volts dc above chassis ground.

1-3. INSTRUMENT IDENTIFICATION.

1-4. Hewlett-Packard uses a two-section, eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 465A described in this manual.

1-5. If the first three digits of the two-section, eight-digit serial number are prefixed with an E or G, your instrument was produced in Europe. An E000-00000 serial number indicates that the instrument was manufactured in England; a G000-00000 serial number indicates that the instrument was manufactured in Germany.

SECTION II

INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions necessary for the installation and shipping of the Model 465A Amplifier. Included are initial inspection procedures, power and grounding requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and be in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or deficiency, see the warranty on the inside front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Model 465A Amplifier can be operated from any source of 115 or 230 volts ($\pm 10\%$), 50-1000 cps. With the instrument disconnected from the ac power source, move the slide switch (located on the rear panel) until desired line voltage appears. Power dissipation is 10 watts maximum.

2-7. GROUNDING REQUIREMENTS.

2-8. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. All Hewlett-Packard instruments are equipped with a three-pronged conductor cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

2-9. To preserve the protection feature when operating the instruments from a two-contact outlet, use a three-prong adapter and connect the green pigtail on the adapter to ground.

2-10. INSTALLATION.

2-11. The Model 465A is fully transistorized. No special cooling is required; however, the instrument should not be operated where the ambient temperature exceeds 55°C (131°F).

2-12. BENCH MOUNTING.

2-13. The Model 465A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument.

2-14. RACK MOUNTING.

2-15. The Model 465A may be rack mounted by using an adapter frame (-hp- Part No. 5060-0797). The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. For additional information, address inquiries to your -hp- Sales and Service Office (see Appendix B for office locations).

2-16. COMBINATION MOUNTING.

2-17. The Model 465A may be mounted in combination with other submodular units by using a Combining Case (-hp- Model 11051A, 11052A, or both, depending on depth). The Combining Case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

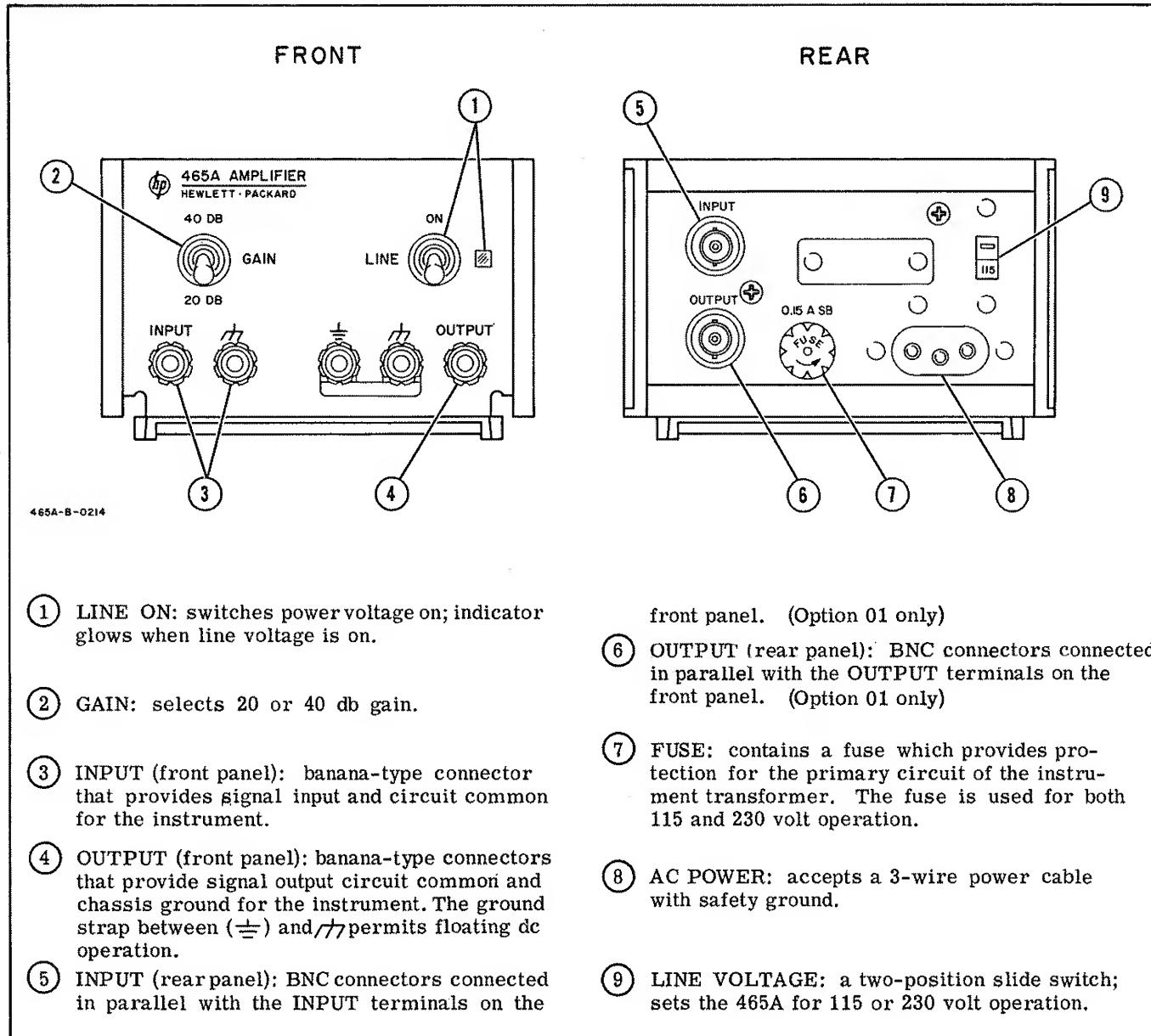


Figure 3-1. Front and Rear Panel Controls, Indicators and Connectors

SECTION III

OPERATING INSTRUCTIONS

3-1. GENERAL.

3-2. The Model 465A Amplifier can be operated as: (1) a general purpose amplifier/preamplifier, (2) oscilloscope preamplifier, (3) oscillator power ampli-

fier, (4) impedance converter (5×10^8 power gain) and (5) in-system amplifier unit.

3-3. DESCRIPTION OF CONTROLS.

3-4. Figure 3-1 gives a description of the front panel and rear panel controls for the 465A.

CAUTION

Ensure that transients greater than ± 200 vdc or ± 25 vdc are not applied to the input or output terminals, respectively. Otherwise damage to the Model 465A may result.

CAUTION

Ensure that common (N) terminals are connected before INPUT or OUTPUT terminals. Otherwise damage to the Model 465A may result due to transients.

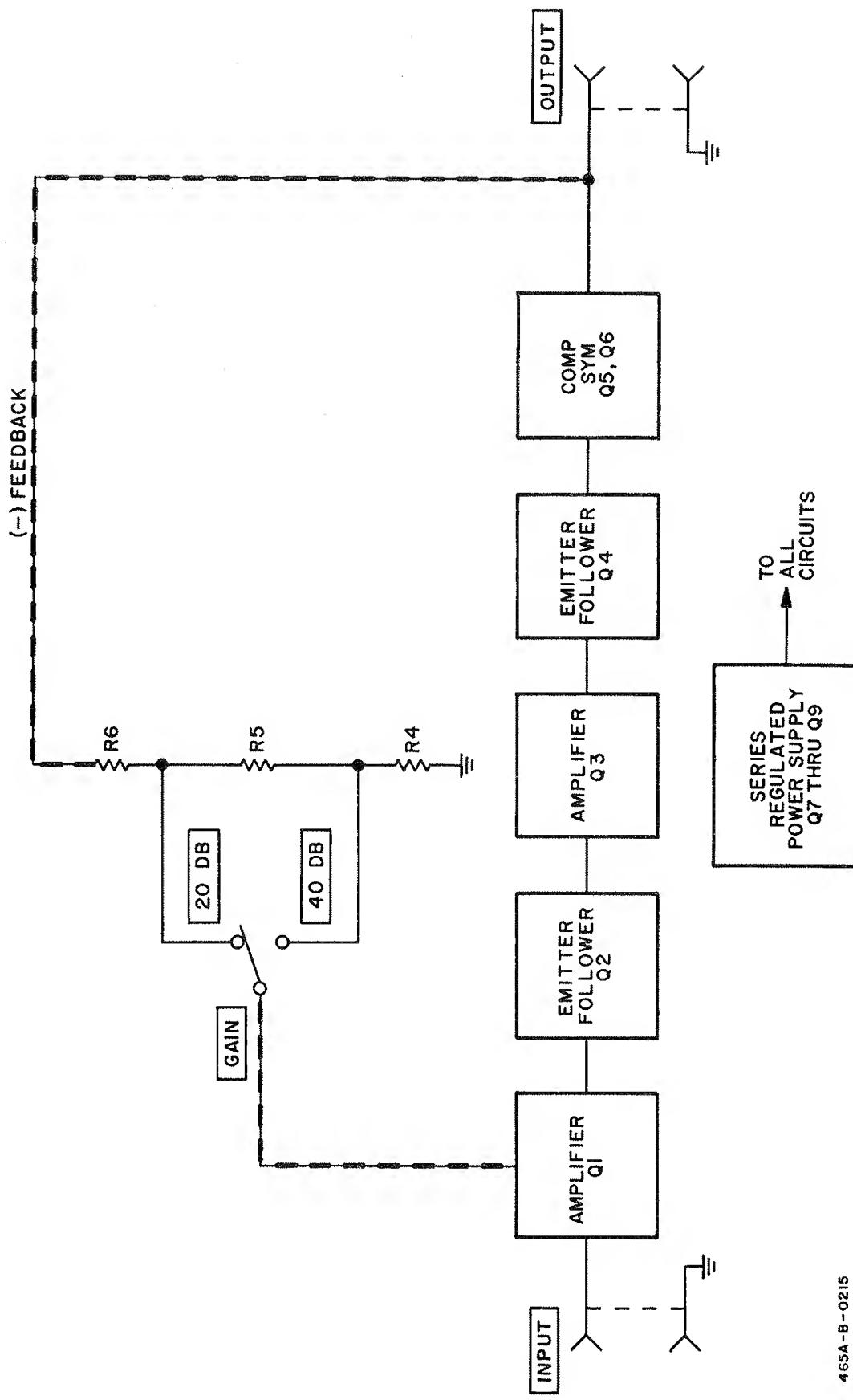


Figure 4-1. Model 465A Amplifier Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. The -hp- Model 465A Amplifier comprises an amplifier section and a power supply section. The amplifier section contains two amplifier stages, two emitter followers and a complementary symmetry pair. The power supply is the series regulated type.

4-3. GENERAL CIRCUIT DESCRIPTION.

4-4. Figure 4-1 shows the block diagram for the 465A Amplifier. Each amplifier stage (Q1 and Q3) is followed by an emitter follower (Q2 and Q4) to prevent loading of the amplifiers. The complementary symmetry pair (Q5 and Q6) provide power gain and low output impedance. Overall feedback, taken from the output and applied differentially to the initial amplification stage decreases distortion and increases gain accuracy. Resistive voltage divider (R4, R5, and R6) changes the amount of feedback to obtain 20 or 40 db gain as selected by the GAIN switch on the front panel. The regulated power supply provides a constant 45 volts to the amplifier circuitry.

4-5. DETAILED CIRCUIT DESCRIPTION.

4-6. Refer to Figure 5-8 for the schematic diagram of the Model 465A Amplifier.

4-7. FIRST AMPLIFICATION STAGE.

4-8. The first amplification stage comprises field effect transistor Q1 and emitter follower Q2. Q1 provides high input impedance and low input noise. Emitter follower Q2 provides isolation while driving the second amplification stage. Q2 also bootstraps Q1 load resistor R10. This permits the field effect transistor to have a gain of approximately 40 db, while operating at an optimum current (for noise) from a 45 volt power supply. C6 and R12 stabilize the overall gain. R13 and C9 allow Q2 to operate as an emitter follower with reduced operating voltage to lower the power dissipation and the noise generation. R2 and R7 set the gate voltage for Q1; Q2 bypasses any ac on the supply, preventing hum injection into Q1.

4-9. SECOND AMPLIFICATION STAGE.

4-10. The second amplification stage consists of amplifier Q3 and emitter follower Q4. Amplifier Q3 is a common emitter stage. When the GAIN switch is on 20 DB, Q3 has 20 db of gain. Q1 and Q3 together give a total of 60 db gain, of which 40 db is used as feedback and 20 db is retained as the closed loop gain. When the GAIN switch is on 40 DB, C11 shunts R22, giving Q3 40 db of gain. The 40 db of feedback is still used, which allows the same gain shaping to be

used in both GAIN switch positions (20 DB and 40 DB). R19 maintains a charge on C11 (in the 20 DB position) to eliminate switching transients while changing gain. R15, R16, R17 and CR1 form the bias voltage divider for Q3, R15 provides bias adjustment and CR1 provides temperature compensation. Emitter follower Q4 isolates and drives the complementary symmetry pair Q5 and Q6.

4-11. OUTPUT CIRCUITRY.

4-12. Q5 and Q6 operate as complementary symmetry emitter followers. CR2 and CR3 forward bias Q5 and Q6 to prevent cross-over distortion. R24 and R25 determine the idling current flowing through Q5 and Q6. A true 50-ohm output impedance for a proper match to the 50-ohm cable or instrument is provided by R26. C15 is the dc blocking capacitor for output; R27 keeps the output voltage at zero volts dc.

4-13. FEEDBACK CIRCUITRY.

4-14. The feedback circuitry controls the amplifier gain by selecting the amount of voltage division by voltage divider R4, R5 and R6. C5 provides phase lead to improve the phase margin around 1 Mc. C4 and C14 eliminate transients during GAIN switching by preventing dc voltages from being applied to the divider stick. Negative feedback is applied to field effect transistor Q1 and differentially compared with the input, which provides improved signal reproduction.

4-15. REGULATED POWER SUPPLY.

4-16. The regulated power supply provides the +45 volts used by the amplifier. A filter circuit, formed by L1, L2, C22 and C23 prevents any interference from being fed into the instrument power line. T1, CR4, CR5 and C16 form a full-wave rectifier. Diode CR6 sets a reference voltage for the emitter circuit of Q7. This reference voltage is compared to the power supply output by Q7, which amplifies the error signal to drive Q8. Transistor Q8, acting as a current amplifier, drives series regulator Q9. Q8 also improves the gain by isolating Q7. C19 and R35 provide gain shaping for high frequency stability of the power supply amplifier. C18 bootstraps R33 by driving it from the output of the regulator. This increases the voltage gain of Q7, which improves voltage regulation of the power supply. Resistors R30, R31 and R32 provide a divided dc voltage proportional to the dc output and close to the reference voltage provided by CR6. This gives Q7 its bias and reference signal, which controls the series regulator. C17 couples all ac output to Q7 to provide better ripple reduction.

Table 5-1. Test Equipment Required

Instrument	Critical Specifications	Use	Recommended Model
DC Voltmeter	Accuracy: $\pm 2\%$ Voltage Range: 50 v full scale	Performance Checks	-hp- Model 3440A/3445A AC-DC Digital Voltmeter
Test Oscillator	Frequency Range: 10 cps to 1 Mc Voltage Output: 1 v	Performance Checks	-hp- Model 651A Test Oscillator
Oscilloscope	Frequency: 2 kc Vertical Sensitivity: 10 v/cm	Troubleshooting	-hp- Model 130C Oscilloscope
AC Voltmeter	Accuracy: $\pm 1\%$, 100 cps to 50 kc $\pm 2\%$, 10 cps to 1 Mc Voltage Range: 10 v Frequency Range: 10 cps to 1 Mc	Performance Checks	-hp- Model 3440A/3445A AC-DC Digital Voltmeter -hp- Model 331A Distortion Analyzer
Variable Voltage Line Transformer	Voltage Range: 103.5 to 126.5 v Output Power: 10 watts	Performance Checks	Superior Electric Co. Type 3PN-116
Ohmmeter	Ohms Range: 10 M ohms	Troubleshooting	-hp- Model 3440A/3445A Multi-Function Unit
Frequency Response Test Set	Frequency: 10 cps to 1 Mc with external oscillator Voltage Output: 10 v	Performance Checks	-hp- Model 739AR Frequency Response Test Set
Distortion Analyzer	Frequency: 10 cps to 500 kc Sensitivity: 1% full scale	Performance Checks	-hp- Model 331A Distortion Analyzer
DC Power Supply	Voltage Output: +45 v Current Limit: 75 ma	Troubleshooting	-hp- Model 723A DC Power Supply
Resistor	1 M ohm, 1%, 1/2 w 50 ohms, 1%, 1 w 1 M ohm, shielded load	Performance Checks	-hp- Part No. 0757-0059 -hp- Part No. 0757-0024 See Figure 5-3

SECTION V

MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary for the proper maintenance of the -hp- Model 465A Amplifier. This section provides the necessary Performance Checks, Adjustment and Calibration Procedures, and Troubleshooting Techniques required to accomplish the above objective.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The test equipment required to perform the operations outlined in this section is listed in Table 5-1. This table describes the type of instrument required, critical specifications, type of operation to be conducted and the recommended model. If the specific model recommended is not available, equipment which meets or exceeds the critical specifications listed may be substituted.

5-5. PERFORMANCE CHECKS.

5-6. The Performance Checks presented in this section are front panel procedures designed to compare the Model 465A with its published specifications. These operations may be incorporated in periodic maintenance, post-repair, or incoming quality control checks. These operations should be conducted before any attempt is made to adjust or calibrate the instrument. During these operations, the Model 465A power line voltage should be periodically varied $\pm 10\%$. A fifteen minute warm-up period should be allowed prior to conducting these checks.

5-7. ACCURACY AND GAIN CHECK.

- a. A Test Oscillator (-hp- Model 651A) and an AC Voltmeter (-hp- Model 3440A/3445A) will be required for this test.
- b. Set Model 465A to 20 db.
- c. Connect test oscillator OUTPUT to Model 465A INPUT. Set oscillator frequency to 1 kc; adjust amplitude for 1.00 v rms output (verify with ac voltmeter).
- d. Connect ac voltmeter to Model 465A OUTPUT. Voltmeter should read between 9.90 and 10.1 v. If correct, adjust oscillator output amplitude for ac voltmeter reading of 1.0 v as measured at output of 465A. This corresponds to an input of 100 mv.
- e. Switch Model 465A to 40 db. AC voltmeter should read between 9.90 and 10.1 v.

5-8. FREQUENCY RESPONSE CHECK.

- a. Figure 5-1 describes the test arrangement recommended. A Test Oscillator (-hp- Model 651A), a Frequency Response Test Set (-hp- Model 739AR) and an AC Voltmeter (-hp- Model 331A and 3440A/3445A) will be required. -hp- Model 3440A/3445A will be used for frequencies from 50 cps to 100 kc; -hp- Model 331A will be used at all other frequencies.
- b. Connect Model 465A as shown in Figure 5-1. Set GAIN to 20 DB.
- c. Set ac voltmeter RANGE to 10 V.

280 MV
P-P

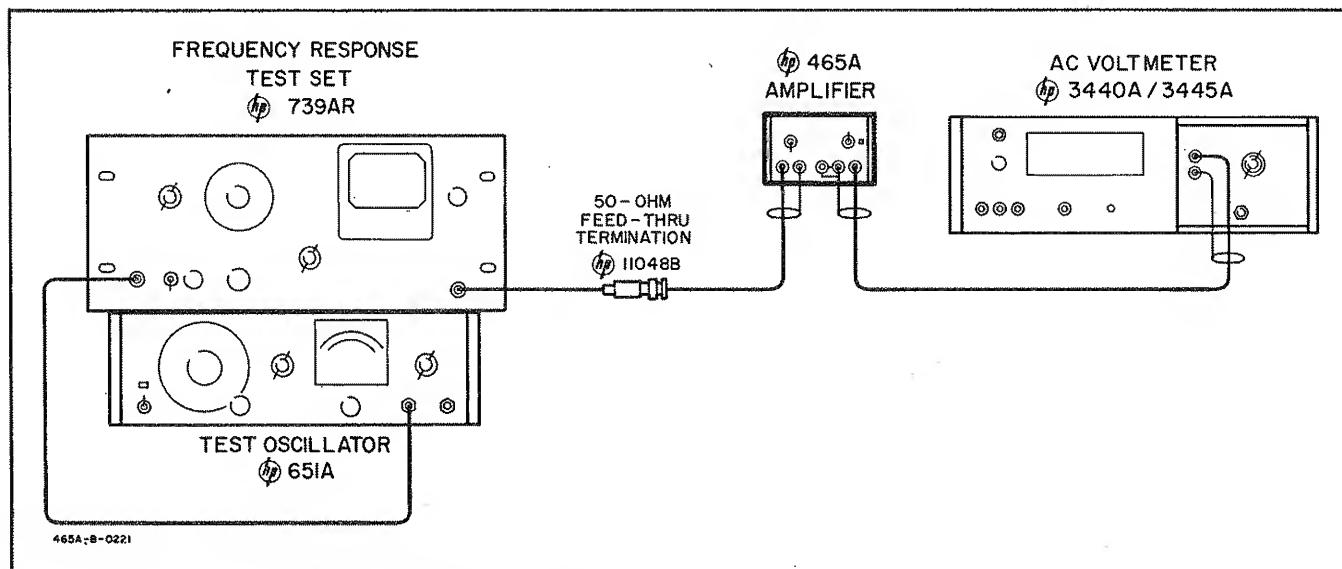


Figure 5-1. Frequency Response Check

Table 5-2. Frequency Response Test

-hp- Model 465A GAIN (db)	Oscillator -hp- Model 651A Range	Frequency (cps)	F. R. T. S. -hp- Model 739AR Output Attenuator	AC Voltmeter -hp- Model 3440A/3445A or 331A Range	Readings
20	1 K	1	1.0	10	9.0 v
20	10	1	1.0	10	08.1 to 09.9 v
20	100	1	1.0	10	08.9 to 09.1 v
20	10 K	5	1.0	10	08.9 to 09.1 v
20	1 M	1	1.0	10	7.2 to 10.8 v
40	1 K	1	.1	10	9.0 v
40	10	1	.1	10	08.1 to 09.9 v
40	100	1	.1	10	08.9 to 09.1 v
40	10 K	5	.1	10	08.9 to 09.1 v
40	1 M	1	.1	10	7.2 to 10.8 v

- d. Set frequency response test set to EXTERNAL; OUTPUT ATTENUATOR to 1.0 .
- e. Set oscillator frequency to 1 kc; adjust output amplitude to provide ac voltmeter reading of 9.0 v.
- f. Adjust frequency response test set METER SET to convenient SET LEVEL.
- g. Reset oscillator frequency to 10 cps. Adjust oscillator amplitude to re-establish SET LEVEL, if required. AC voltmeter should read between 8.1 and 9.9 v.
- h. Repeat step g above for oscillator frequencies listed in Table 5-2. AC voltmeter should read within limits specified.
- j. When going from 20 db to 40 db, re-adjust oscillator output for ac voltmeter reading of 9.0 v at 1 kc. Reset frequency response test set METER SET for SET LEVEL. Repeat above test using frequency settings provided in Table 5-2.

5-9. INPUT IMPEDANCE CHECK.

- a. A Test Oscillator (-hp- Model 651A), an AC Voltmeter (-hp- Model 3440A/3445A) and a 1 M ohm $\pm 1\%$, 1/2 watt resistor (-hp- Part No. 0757-0059) will be required.
- b. Set Model 465A GAIN to 20 db.
- c. Connect ac voltmeter to Model 465A OUTPUT. Set RANGE to 10 V.
- d. Connect oscillator OUTPUT to Model 465A INPUT. Set oscillator frequency to 100 cps; adjust output amplitude for ac voltmeter reading of 10 v.
- e. Insert 1 M ohm resistor in series with osci-

llator and Model 465A INPUT (resistor must be connected directly to Model 465A INPUT with nothing else across input terminals). AC voltmeter should read approximately 9.1 v (± 0.4 v). This verifies a Model 465A input resistance of 10 M ohms.

f. Reset oscillator frequency to 10 kc. Insure that oscillator output is still 1.0 v. AC voltmeter should read more than 6.0 v. This verifies a Model 465A input impedance of 10 M ohms, shunted by 20 pf.

5-10. OUTPUT IMPEDANCE CHECK.

- a. A Test Oscillator (-hp- Model 651A), an AC Voltmeter (-hp- Model 331A) and a 50 ohm $\pm 1\%$, 1 watt resistor (-hp- Part No. 0727-0024) will be required for this test.
- b. Set Model 465A GAIN to 20 db.
- c. Connect ac voltmeter to Model 465A OUTPUT; set RANGE to 10 V.
- d. Connect oscillator OUTPUT to Model 465A INPUT. Set frequency to 1 kc; adjust output for ac voltmeter reading of 10 v.
- e. Place 50 ohm resistor across Model 465A OUTPUT. AC voltmeter reading should drop to 5.0 v. This verifies Model 465A output impedance of 50 ohms.

5-11. DISTORTION CHECK.

- a. Figure 5-2 describes the test arrangement recommended. A Test Oscillator (-hp- Model 651A), a Distortion Analyzer (-hp- Model 331A) and a Frequency Response Test Set (-hp- Model 739AR) will be required.
- b. Connect Model 465A as shown in Figure 5-2.

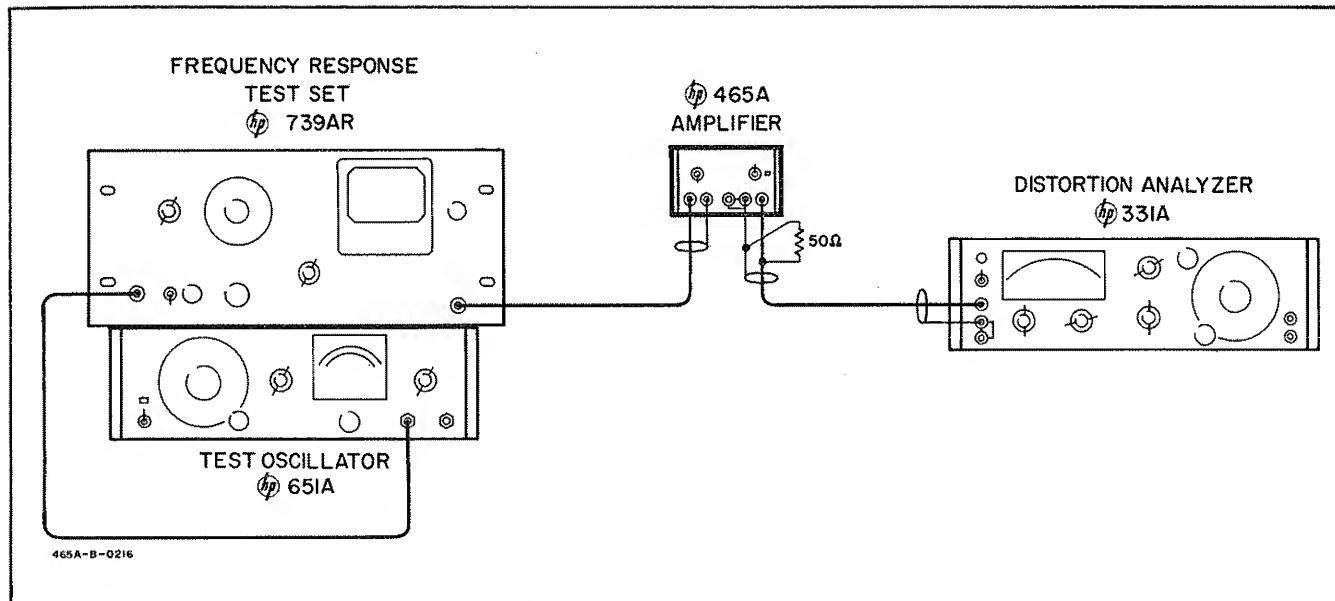


Figure 5-2. Distortion Check

- c. Set Model 465A GAIN to 20 DB.
- d. Set distortion analyzer to METER.
- e. Set oscillator frequency to 1 kc; adjust oscillator output to provide distortion analyzer (voltmeter) reading of 5 v.
- f. Adjust frequency response test set METER SET control to desired SET LEVEL.
- g. Switch distortion analyzer FUNCTION to SET LEVEL; METER RANGE to SET LEVEL and SENSITIVITY for upscale meter deflection. Adjust VERNIER for full scale reading of 1 (100%).
- h. Rotate FUNCTION switch to DISTORTION. Null out fundamental of signal by alternately reducing METER RANGE and adjusting BALANCE and frequency control knob for null.
- j. Final null will indicate amount of distortion (%) present in Model 465A output signal. At 1 kc, distortion should be less than 1%.
- k. Repeat the above test for oscillator frequencies listed in Table 5-3. Entire test should be repeated with Model 465A GAIN set to 40 db. Refer to Table 5-3 for oscillator frequencies and distortion tolerances. Monitor frequency response test set SET LEVEL to insure constant oscillator output amplitude.

Table 5-3. Distortion Check

-hp- Model 465A Gain (db)	Oscillator -hp- Model 651A		Distortion Analyzer -hp- Model 331A	
	Frequency	Output	Frequency	Maximum Disposition
20	1 kc	1.0 v	1 kc	1%
20	50 kc	1.0 v	50 kc	1%
20	500 kc	1.0 v	500 kc	2%
20	10 cps	1.0 v	10 cps	1%
40	1 kc	0.1 v	1 kc	1%
40	50 kc	0.1 v	50 kc	1%
40	500 kc	0.1 v	500 kc	2%
40	10 cps	0.1 v	10 cps	1%

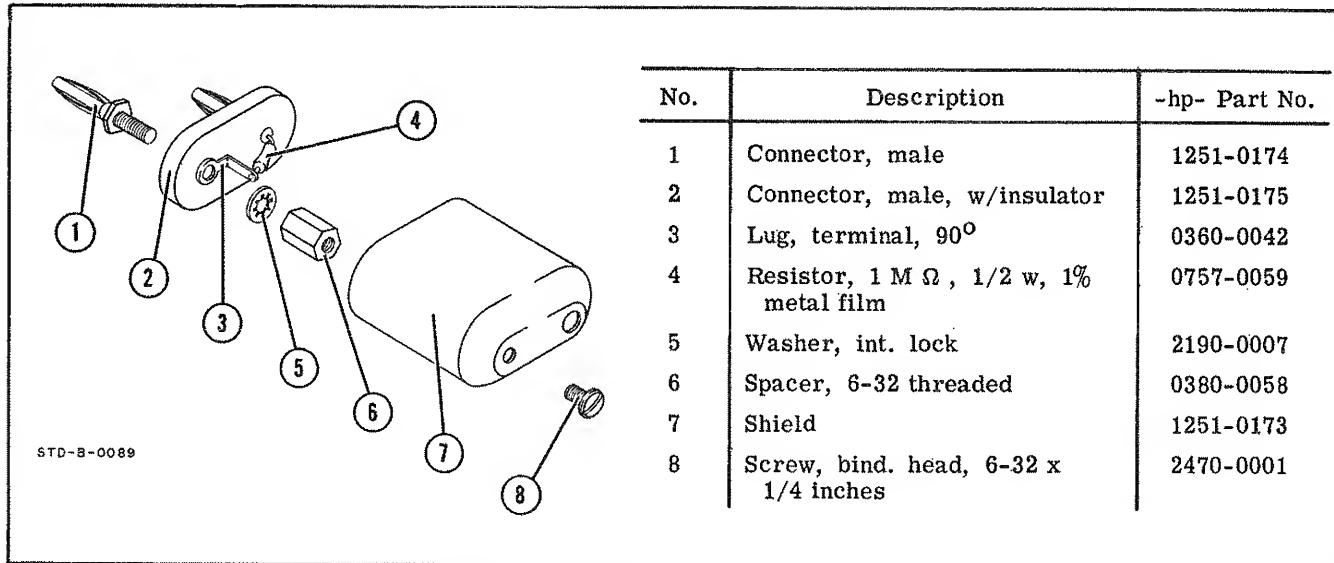


Figure 5-3. Shielded Load for Residual Noise Check

5-12. NOISE CHECK.

- An AC Voltmeter (-hp- Model 331A) and a 1 megohm shielded resistor (refer to Figure 5-3) will be required for this test.
- Connect ac voltmeter to Model 465A OUTPUT; RANGE to .003 V.
- Set Model 465A GAIN to 40 db.
- Connect 1 megohm shielded resistor across Model 465A INPUT.
- AC voltmeter must read less than 2.5 mv (or 25 microvolts referred to input).

5-13. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-14. The following is a complete Adjustment and Calibration Procedure for the -hp- Model 465A Amplifier. These operations should be conducted only if it has previously been established by the Performance Checks, Paragraph 5-5, that the Model 465A is out of adjustment. Indiscriminate adjustment of the internal controls to "refine" readings may actually cause more difficulty. If the procedures outlined below do not rectify any discrepancies which may exist, and all connections and settings have been rechecked, refer to Paragraph 5-21, Troubleshooting Techniques, for possible cause and recommended corrective action.

5-15. POWER SUPPLY ADJUST (+45 V).

- A DC Voltmeter (-hp- Model 3440A/3445A) will be required for this test.
- Set voltmeter FUNCTION to DC; RANGE to 100 V.

c. Connect positive lead to + side of C20; common lead to common. DC voltmeter should read +45 v (± 1 v).

d. If not, adjust R32 for proper reading.

5-16. BIAS ADJUST (R15).

- A DC Voltmeter (-hp- Model 3440A/3445A) will be required for this test.
- Set dc voltmeter FUNCTION to DC; RANGE to 100 V.
- Connect positive lead to + side of C15; common lead to common. DC voltmeter should read +23 v (± 0.5 v).
- If not, adjust R15 to obtain proper reading.

5-17. 1 MC ADJUST (C5).

- A Test Oscillator (-hp- Model 651A) and an AC Voltmeter (-hp- Model 331A) will be required for this test.
- Set Model 465A GAIN to 20 db.
- Connect oscillator OUTPUT to Model 465A INPUT. Set oscillator frequency to 1 Mc; adjust output to 1.0 v rms (use ac voltmeter to verify).
- Connect ac voltmeter to Model 465A OUTPUT.
- Adjust C5 for ac voltmeter reading of 8.5 v.

5-18. SERVICING ETCHEd CIRCUIT BOARD.

5-19. The -hp- Model 465A has one etched circuit board. Use caution when removing it to avoid damaging mounted components. The -hp-

number for the assembly is silk screened on the exterior of the circuit board to identify it. Refer to Section VI for parts replacement and -hp- part number information.

5-20. The etched circuit board is a plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules.

- a. Use a low-heat (25 to 30 watts) small-tip soldering iron, and a small diameter rosin core solder.
- b. Circuit components can be removed by placing the soldering iron on the component lead on either side of the board, and pulling up on lead. If a component is obviously damaged, clip leads as close to components as possible and then remove. Excessive heat can cause the circuit and board to separate, or cause damage to the component.
- c. Component lead hole should be cleaned with a toothpick or other appropriate device before inserting new lead.
- d. To replace components, shape new leads and insert them in holes. Reheat with iron, and add solder as required to insure a good electrical connection.
- e. Clean excess flux from the connection and adjoining area.

5-21. TROUBLESHOOTING TECHNIQUE.

5-22. This section contains procedures designed to assist in the isolation of malfunctions. These procedures are based on a systematic analysis of the instrument circuitry. These operations should be

undertaken only after it has been established that the difficulty can not be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-13. An investigation should also be made to insure that the trouble is not a result of conditions external to the Model 465A.

5-23. Conduct a visual check of the Model 465A for possible burned or loose components, loose connections, or any other obvious conditions which might suggest a source of trouble.

5-24. Table 5-4 contains a summary of the front-panel symptoms that may be encountered. It should be used in initial efforts to select a starting point for troubleshooting operations.

5-25. Table 5-5, in conjunction with Figure 5-4, contains procedures which may be used as a guide in isolating malfunctions. The steps in Table 5-5 describe the normal conditions which should be encountered during the checks (circled numbers (N)) in Figure 5-4.

5-26. The checks outlined in Table 5-5 are not designed to measure all circuit parameters, rather, only to localize the malfunction. Therefore, it is quite possible that additional measurements may be required to completely isolate the problem. Component values may vary slightly between instruments; therefore, it should not be necessary to precisely duplicate voltage values described.

5-27. The conditions discussed in Table 5-5 and Figure 5-4 are based on the following criteria: (1) the + side of C14 is removed from circuit, opening the feedback loop; (2) Model 465A GAIN set to 40 db; and (3) 1 mv, 2 kc signal applied to Model 465A INPUT.

Table 5-4. Front Panel Troubleshooting

Front Panel Symptoms	Possible Cause
Line Lamp not glowing	Check fuse F1, L1, L2, S1, R28, S2 or T1
Functions properly on 20 db position only	Check R3, R4, R5, R6 and Bias Voltages
Functions properly on 40 db position only	Check Bias Voltages and Q1, Q2.

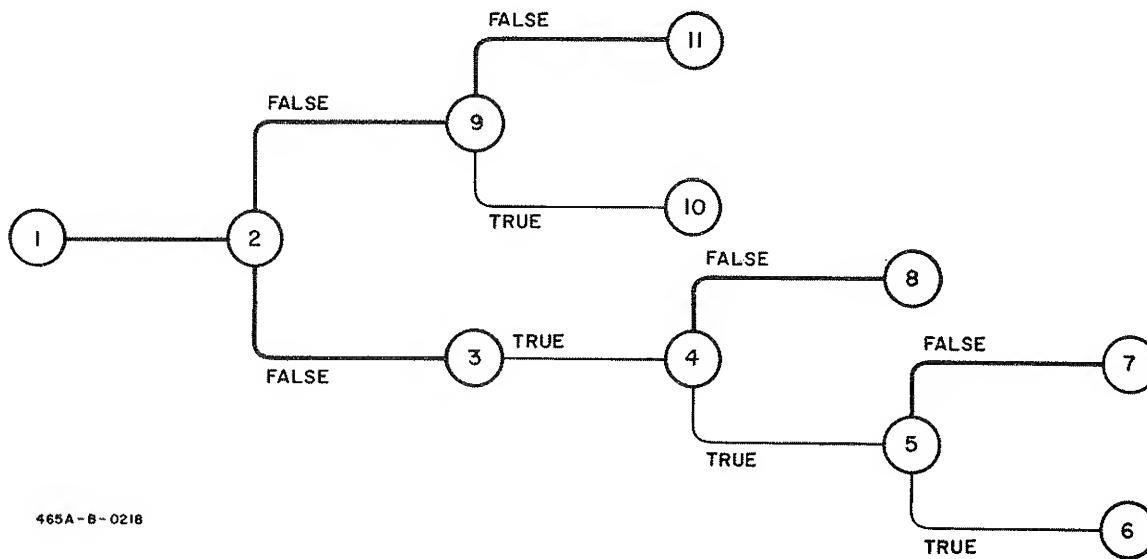


Figure 5-4. Troubleshooting Tree

Table 5-5. Troubleshooting

①	Remove the + side of C14 from the circuit board. Set Model 465A GAIN to 40 db. Apply a 1.0 mv, 2 kc input signal.	⑦	Check Q4, Q5 and Q6. Refer to Figure 5-8 for typical dc voltage levels.
②	Measure the dc voltage at the + side of C20. Should be +45 v (± 1 v). If correct, proceed to ③ ; if incorrect, go directly to ⑨ .	⑧	Check Q1, Q2 and Q3. Refer to Figure 5-8 for typical dc voltage levels.
③	Observe the ac waveform at the Model 465A OUTPUT. Should be a sine wave with peak voltage of approximately 12.7 v (9 v rms). If incorrect, proceed to ④ .	⑨	Disconnect jumper wire at the + side of C20, removing power supply from circuit. Measure dc voltage at the + side of C20. Should be +45 v (± 1 v). If correct, proceed to ⑩ ; if incorrect, go directly to ⑪ .
④	Observe the ac waveform at the base of Q4. Should be a sine wave with peak voltage of approximately 12.7 v (9 v rms). If correct, proceed to ⑤ ; if incorrect, go directly to ⑧ .	⑩	Connect a DC Power Supply (-hp- Model 723A) to the collectors of Q5 and Q6. Connect the high side to the collector of Q5; the low side to the collector of Q6. Adjust the power supply output to +45 v; set current limit to 75 ma. If power supply indicates current limit, check Q4, Q5, Q6 and CR2-3 for short.
⑤	Observe the ac waveform at the junction of R24 and R25. Should be a sine wave with peak voltage approximately 12.7 v (9 v rms). If correct, proceed to ⑥ ; if incorrect, go directly to ⑦ .	⑪	Check Model 465A power supply to include T1 secondary, Q7, CR6, Q8 and Q9. Refer to Figure 5-8 for typical dc voltage levels.
⑥	Check R26, R27 and C15.		

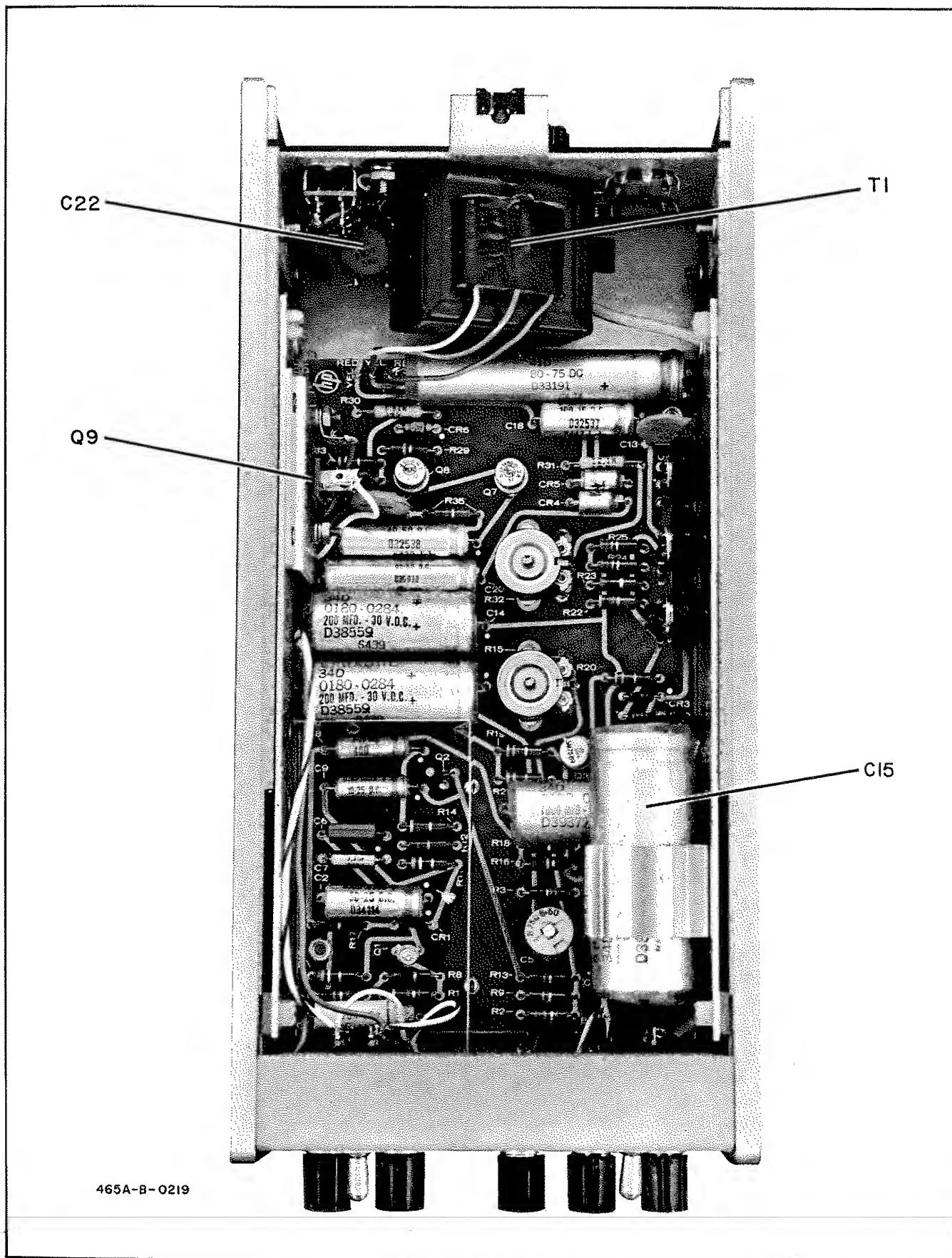
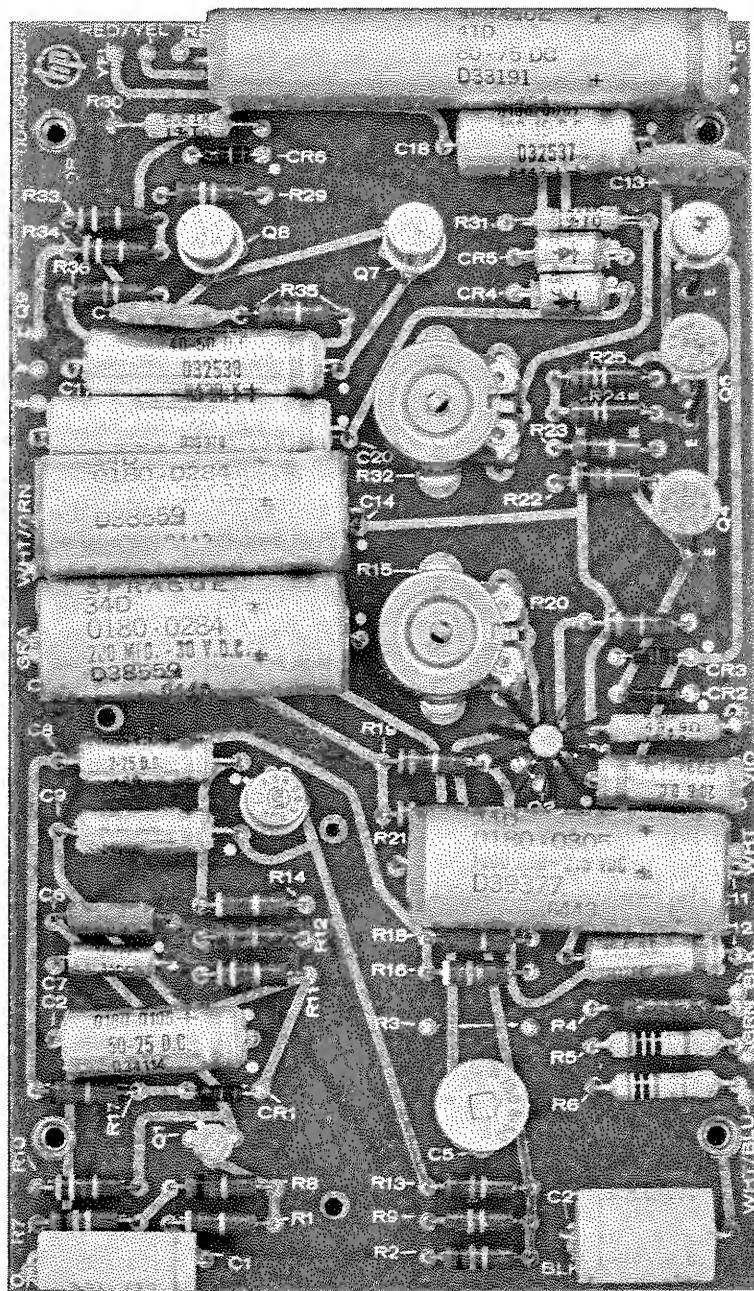
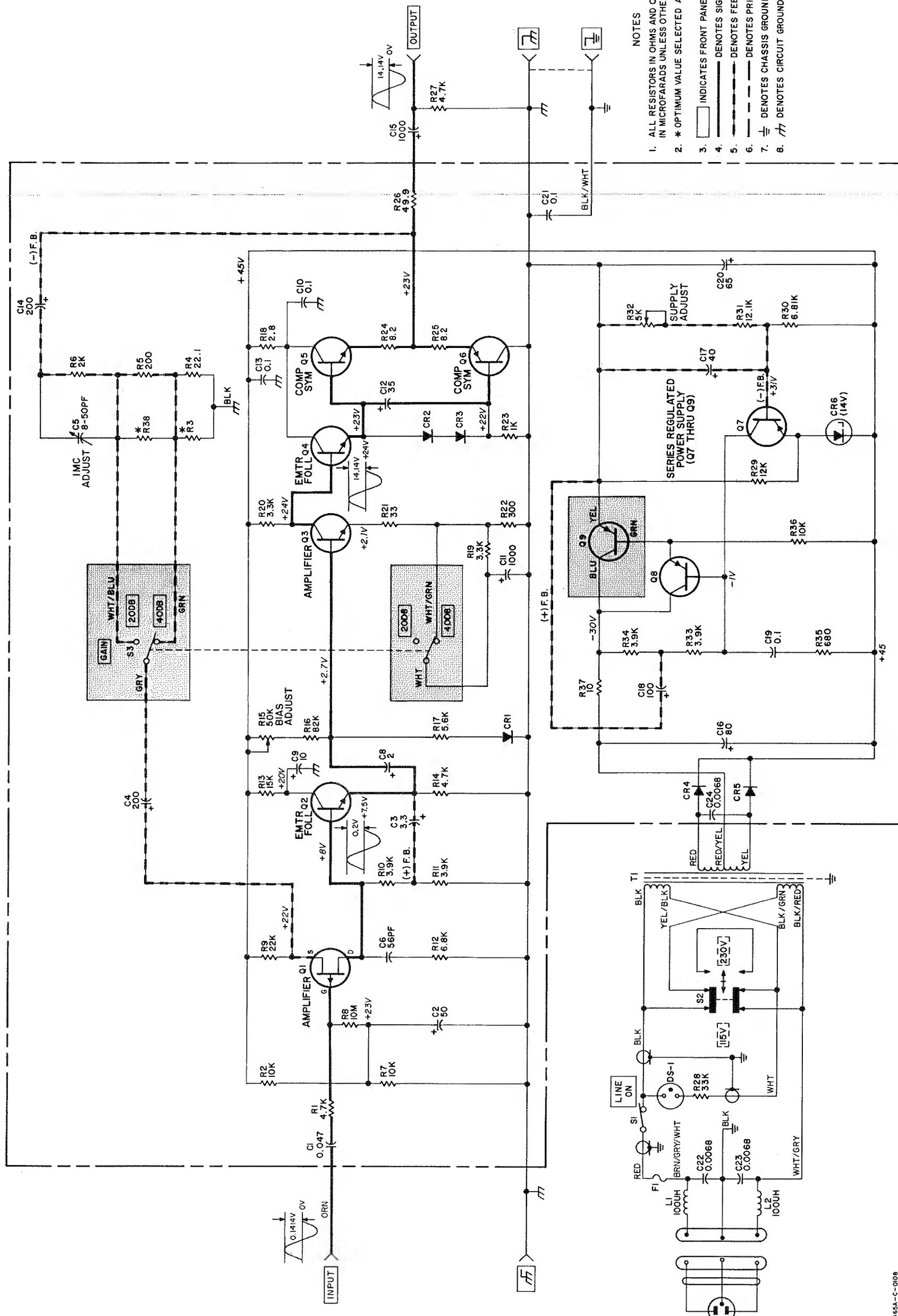


Figure 5-5. Top View



465A-A-0220

Figure 5-6. Printed Circuit Board, Parts Location



NOTES

1. ALL RESISTORS IN OHMS AND CAPACITORS IN MICROFARADS UNLESS OTHERWISE DESIGNATED.
2. * OPTIMUM VALUE SELECTED AT FACTORY.
3. □ INDICATES FRONT PANEL LOCATION.
4. — INDICATES SIGNAL PATH.
5. - - - INDICATES FEEDBACK.
6. - - - INDICATES PRINTED CIRCUIT BOARD.
7. - - - INDICATES CHASSIS GROUND.
8. // INDICATES CIRCUIT GROUND.

Figure 5-7. Amplifier Schematic
5-9-5-10

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphabetical order of their reference designators and indicates the description and -hp- part number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their -hp- part number and provides the following information on each part:

- a. Description of the part (see list of abbreviations below).
- b. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).
- c. Manufacturer's part number.
- d. Total quantity used in the instrument (TQ column).

6-3. Miscellaneous parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard part numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

- a. Instrument model number.
- b. Instrument serial number.
- c. Description of the part.
- d. Function and location of the part.

REFERENCE DESIGNATORS

A	= assembly	F	= fuse	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
B	= motor	FL	= filter	Q	= transistor	W	= cable
C	= capacitor	J	= jack	R	= resistor	X	= socket
CR	= diode	K	= relay	RT	= thermistor	XF	= fuseholder
DL	= delay line	L	= inductor	S	= switch	XDS	= lampholder
DS	= device signaling (lamp)	M	= meter	T	= transformer	Z	= network
E	= misc electronic part	MP	= mechanical part				

ABBREVIATIONS

a	= amperes	elect	= electrolytic	mtg	= mounting	rot	= rotary
bp	= bandpass	encap	= encapsulated	my	= mylar	rms	= root-mean-square
bwo	= backward wave oscillator	f	= farads	NC	= normally closed	rmo	= rack mount only
		fxd	= fixed	Ne	= neon	s-b	= slow-blow
c	= carbon	Ge	= germanium	NO	= normally open	Se	= selenium
cer	= ceramic	grd	= ground (ed)	NPO	= negative positive zero (zero temperature coefficient)	sect	= section(s)
cmo	= cabinet mount only	h	= henries	nsr	= not separately replaceable	Si	= silicon
coef	= coefficient	Hg	= mercury	o	= order by description	sil	= silver
com	= common	impg	= impregnated	obd	= order by description	sl	= slide
comp	= composition	incd	= incandescent	p	= peak	td	= time delay
conn	= connection	ins	= insulation (ed)	pc	= printed circuit board	TiO ₂	= titanium dioxide
crt	= cathode-ray tube			pf	= picofarads = 10 ⁻¹² farads	tog	= toggle
dep	= deposited			pp	= peak to peak	tol	= tolerance
EIA	= Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by stock numbers.	K	= kilo = 1000	piv	= peak inverse voltage	trim	= trimmer
		lin	= linear taper	pos	= position (s)	twt	= traveling wave tube
		log	= logarithmic taper	poly	= polystyrene	var	= variable
		m	= milli = 10 ⁻³	pot	= potentiometer	w/	= with
		M	= megohms	rect	= rectifier	W	= watts
		ma	= milliamperes			ww	= wirewound
		μ	= micro = 10 ⁻⁶			w/o	= without
		minat	= miniature			*	= optimum value selected at factory, average value shown (part may be omitted)
		mfgl	= metal film on glass				
		mfr	= manufacturer				

Table 6 - 1. Reference Designation Index

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
A1R7	0687-1031	R: fxd, comp, 10 K ohms $\pm 10\%$, 1/2 w	
A1R8	0687-1061	R: fxd, comp, 10 M ohms $\pm 10\%$, 1/2 w	
A1R9	0687-2231	R: fxd, comp, 22 K ohms $\pm 10\%$, 1/2 w	
A1R10 and A1R11	0687-3921	R: fxd, comp, 3300 ohms $\pm 10\%$, 1/2 w	
A1R12	0687-6821	R: fxd, comp, 6800 ohms $\pm 10\%$, 1/2 w	
A1R13	0687-1531	R: fxd, comp, 15 K ohms $\pm 10\%$, 1/2 w	
A1R14	0687-4721	R: fxd, comp, 4700 ohms $\pm 10\%$, 1/2 w	
A1R15	2100-0094	R: var, comp, lin taper, 50 K ohms $\pm 30\%$, 0.10 w	
A1R16	0686-8235	R: fxd, comp, 82 K ohms $\pm 5\%$, 1/2 w	
A1R17	0687-5621	R: fxd, comp, 5600 ohms $\pm 10\%$, 1/2 w	
A1R18	0698-0001	R: fxd, comp, 4.7 ohms $\pm 5\%$, 1/2 w	
A1R19 and A1R20	0687-3321	R: fxd, comp, 3300 ohms $\pm 10\%$, 1/2 w	
A1R21	0686-3305	R: fxd, comp, 33 ohms $\pm 5\%$, 1/2 w	
A1R22	0686-3015	R: fxd, comp, 300 ohms $\pm 5\%$, 1/2 w	
A1R23	0687-1021	R: fxd, comp, 1000 ohms $\pm 10\%$, 1/2 w	
A1R24 and A1R25	0690-0003	R: fxd, comp, 8.2 ohms $\pm 10\%$, 1/2 w	
A1R26	0757-0072	R: fxd, 49.9 ohms $\pm 1\%$ Not Assigned	
A1R27 and A1R28			
A1R29	0687-1231	R: fxd, comp, 12 K ohms $\pm 10\%$, 1/2 w	
A1R30	0757-0835	R: fxd, 6.81 K ohms $\pm 1\%$	
A1R31	0757-0841	R: fxd, 12.1 K ohms $\pm 1\%$	
A1R32	2100-0091	R: var, comp, lin taper, 5 K ohms $\pm 30\%$, 0.15 w	
A1R33 and A1R34	0687-3921	R: fxd, comp, 3300 ohms $\pm 10\%$, 1/2 w	
A1R35	0687-1511	R: fxd, comp, 150 ohms $\pm 10\%$, 1/2 w	
A1R36	0687-1531	R: fxd, comp, 15 K ohms $\pm 10\%$, 1/2 w	
A1R37	0687-1001	R: fxd, comp, 10 ohms $\pm 10\%$, 1/2 w	
C1 thru C14		Not Assigned	
C15	0180-0378	C: fxd, alum elect -10% +100%	
C16 thru C21		Not Assigned	
C22 and C23	0150-0097	C: fxd, ceramic, .0068 μ f $\pm 2\%$, 1000 vdcw	
DS1	2140-0015	Lamp, glow	
F1	2110-0017	Fuse: cartridge, 0.15 amp	
L1 and L2	9140-0029	Coil - R. F.	
Q1 thru Q8		Not Assigned	
Q9	1850-0098	Transistor: germanium, PNP	
R1 thru R26		Not Assigned	
R27	0687-4721	R: fxd, comp, 4700 ohms $\pm 10\%$, 1/2 w	
R28	0684-3331	R: fxd, comp, 33 K ohms $\pm 10\%$, 1/4 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	-hp- PART NO.	DESCRIPTION	NOTE
S1	3101-0037	Switch: toggle, SPST, 3 amp	
S2	3101-0033	Switch: slide, DPDT	
S3	3101-0038	Switch: toggle, DPDT, 3 amp	
T1	9100-0343	Transformer: power	
W1	8120-0078	Cable Ass'y, Power: black, extra limp, 7.5 ft. long	
		<u>MISCELLANEOUS</u>	
	0340-0099	Insulator: grey, plastic	
	0340-0100	Insulator: grey, plastic	
	1200-0043	Insulator	
	1200-0081	Insulator	
	1205-0050	Heat + sink	
	>1250-0252	Connector: R. F.	
	1251-1009	Connector: power	
	1400-0084	Holder - fuse	
	1490-0031	Stand - tilt	
	1510-0010	Binding Post - red	
	1510-0011	Binding Post - black	
	5000-0700	Cover - side	
	5000-0711	Cover - bottom	
	5020-0700	Spacer - CAB	
	5040-0234	Jewel - pilot light	
	5040-0235	Base - pilot light	
	5040-0700	Hinge	
	5060-0700	Frame Ass'y	
	5060-0709	Cover - top	
	5060-0727	Foot - Ass'y	
	5060-4916	Terminal - ground, black	
	00465-00101	Plate - right	
	00465-00102	Plate - left	
	00465-00201	Panel - front	
	00465-00202	Panel - rear	
	00465-01201	Bracket - transistor	
	00465-90000	Manual - Operating and Service	

> Option 01 only

See introduction to this section

Table 6-2. Replaceable Parts

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
0130-0017	C: var, ceramic, 8-50 pf	72982	557-019-U2PO-34 R	1	
0140-0014	C: fxd, molded mica, 56 pf $\pm 10\%$	04062	RCM15E 560K	1	
0150-0084	C: fxd, ceramic, die, .1 μ f $\pm 80\%$ -20%, 50 vdcw	56289	33C41	3	
0150-0097	C: fxd, ceramic, .0068 μ f $\pm 2\%$, 1000 vdcw	91418	B	2	
0170-0022	C: fxd, my die, 0.1 μ f $\pm 20\%$, 600 vdcw	01281	HEW-17	1	
0170-0060	C: fxd, my die, .047 mf $\pm 10\%$, 400 vdcw	01281	Type 663UW	1	
0180-0050	C: fxd, alum elect, 40 μ f -15% +100%, 50 vdcw	56289	D32538	1	
0180-0059	C: fxd, elect, 10 μ f -10% +100%, 25 vdcw	56289	30D106G025BB4	1	
0180-0061	C: fxd, elect, 100 μ f +100% -10%, 15 vdcw	56289	30D107G015DD4	1	
0180-0064	C: fxd, elect, 35 μ f -10% +100%, 6 vdcw	56289	30D156G006BB4	1	
0180-0105	C: fxd, alum elect, 50 μ f -10%, +100%, 25 vdcw	56289	D34114	1	
0180-0110	C: fxd, alum elect, 80 μ f, 75 vdcw	56289	41D D33191	1	
0180-0111	C: fxd, alum elect, 2 μ f, 25 vdcw	56289	40D 173A2	1	
0180-0149	C: fxd, alum elect, -10% +100%	56289	Type 30D	1	
0180-0161	C: fxd, tanta elect, $\pm 20\%$	56289	150D335 X 0035 B2	1	
0180-0284	C: fxd, alum elect -10% +75%	56289	D38559	2	
0180-0305	C: fxd, alum elect -10% +100%	56289	34D108H2R5FJ4	1	
0180-0378	C: fxd, alum elect, -10% +100%	56289	34D108H030JP4	1	
0340-0099	Insulator: grey, plastic	28480	0340-0099	1	
0340-0100	Insulator: grey, plastic	28480	0340-0100	1	
0684-3331	R: fxd, comp, 33 K ohms $\pm 10\%$, 1/4 w	01121	CB 3331	1	
0686-3015	R: fxd, comp, 300 ohms $\pm 5\%$, 1/2 w	01121	EB 3015	1	
0686-3305	R: fxd, comp, 33 ohms $\pm 5\%$, 1/2 w	01121	EB 3305	1	
0686-8235	R: fxd, comp, 82 K ohms $\pm 5\%$, 1/2 w	01121	EB 8235	1	
0687-1001	R: fxd, comp, 10 ohms $\pm 10\%$, 1/2 w	01121	EB 1001	1	
0687-1021	R: fxd, comp, 1000 ohms $\pm 10\%$, 1/2 w	01121	EB 1021	1	
0687-1031	R: fxd, comp, 10 K ohms $\pm 10\%$, 1/2 w	01121	EB 1031	2	
0687-1061	R: fxd, comp, 10 M ohms $\pm 10\%$, 1/2 w	01121	EB 1061	1	
0687-1231	R: fxd, comp, 12 K ohms $\pm 10\%$, 1/2 w	01121	EB 1231	1	
0687-1511	R: fxd, comp, 150 ohms $\pm 10\%$, 1/2 w	01121	EB 1511	1	
0687-1531	R: fxd, comp, 15 K ohms $\pm 10\%$, 1/2 w	01121	EB 1531	2	
0687-2231	R: fxd, comp, 22 K ohms $\pm 10\%$, 1/2 w	01121	EB 2231	1	
0687-3321	R: fxd, comp, 3300 ohms $\pm 10\%$, 1/2 w	01121	EB 3321	1	
0687-3921	R: fxd, comp, 3.9 K ohms $\pm 10\%$, 1/2 w	01121	EB 3921	2	
0687-4721	R: fxd, comp, 4700 ohms $\pm 10\%$, 1/2 w	01121	EB 4721	3	
0687-5621	R: fxd, comp, 5600 ohms $\pm 10\%$, 1/2 w	01121	EB 5621	1	
0687-6821	R: fxd, comp, 6800 ohms $\pm 10\%$, 1/2 w	01121	EB 6821	1	
0698-0001	R: fxd, comp, 4.7 ohms $\pm 5\%$, 1/2 w	01121	EB 47G5	1	
0698-3186	R: fxd, 200 ohms $\pm 1/2\%$	19701	CEC T-O	1	
0698-3187	R: fxd, 2 K $\pm 1/2\%$	19701	MF7C T-O	1	
0699-0003	R: fxd, comp, 8.2 ohms $\pm 10\%$, 1/2 w	01121	EB 82G1	1	
0757-0072	R: fxd, 49.9 ohms $\pm 1\%$	19701	MF7C T-O	1	
0757-0835	R: fxd, 6.81 K ohms $\pm 1\%$	19701	MF7C T-O	1	
0757-0841	R: fxd, 12.1 K ohms $\pm 1\%$	19701	MF7C T-O	1	
0757-0992	R: fxd, met film, 22.1 ohms $\pm 1\%$, 1/2 w	19701	MF7C T-O	1	

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

-hp- PART NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
1200-0043	Insulator	71785	293011	1	
1200-0081	Insulator: bushing, nylon	26365	974	1	
1205-0050	Heat - sink	91506	9017-1G1	1	
>1250-0252	Connector: R. F.	06140	30288-1	2	
1251-1009	Connector: ac power cord receptacle	82389	AC-3	1	
1400-0084	Holder - fuse	75915	342014	1	
1490-0031	Stand - tilt	91260	obd #	1	
1510-0010	Binding Post - red	28480	1510-0010	2	
1510-0011	Binding Post - black	28480	1510-0011	2	
1850-0098	Transistor: germanium, PNP	77068	B-1493	1	
1850-0128	Transistor: germanium, PNP, 2N398B	86684	2N398B	1	
1853-0017	Transistor: Si, PNP	04713	obd #	1	
1854-0033	Transistor: Si, NPN, 2N3391	24446	2N3391	1	
1854-0039	Transistor: Si, NPN, 2N3053	86684	2N3053	1	
1854-0070	Transistor: Si, NPN	24446	obd #	1	
1855-0004	Transistor: P channel	17856	U112	1	
1901-0025	Diode: Si	93332	D3072	1	
1901-0026	Diode: Si, 200 PIV	11711	obd #	1	
1902-0040	Diode: breakdown, 400 mw	04713	SZ10939-224	1	
2100-0091	R: var, comp, lin taper, 5 K ohms $\pm 30\%$, 0.15 w	71450	UPE 70RE	1	
2100-0094	R: var, comp, lin taper, 50 K ohms $\pm 30\%$, 0.10 w	71450	UPE 70RE	1	
2110-0017	Fuse - cartridge, 0.15 amp	98997	3AG-TL-15/100	1	
2140-0015	Lamp, glow	24455	obd #	1	
3101-0033	Switch - slide, DPDT	79727	G-326	1	
3101-0037	Switch - toggle, SPST, 3 amp	04009	83050-A	1	
3101-0038	Switch - toggle, DPDT, 3 amp	04009	83054-B	1	
5000-0700	Cover - side	28480	5000-0700	1	
5000-0711	Cover - bottom	28480	5000-0711	1	
5020-0700	Spacer - CAB	28480	5020-0700	1	
5040-0234	Jewel - pilot light	28480	5040-0234	1	
5040-0235	Base - pilot light	28480	5040-0235	1	
5040-0700	Hinge	28480	5040-0700	1	
5060-0700	Frame Ass'y	28480	5060-0700	1	
5060-0709	Cover - top	28480	5060-0709	1	
5060-0727	Foot Ass'y	28480	5060-0727	1	
5060-4916	Terminal - ground, black	28480	5060-4916	1	
8120-0078	Cable Ass'y, power: black, extra limp, 7.5 ft. long	70903	KH-4147	1	
9100-0343	Transformer, power	28480	9100-0343	1	
9140-0029	Coil - R. F.	99848	3100-15-101	2	
00465-00101	Plate - right	28480	00465-00101	1	
00465-00102	Plate - left	28480	00465-00102	1	
00465-00201	Panel - front	28480	00465-00201	1	
00465-00202	Panel - rear	28480	00465-00202	1	
00465-01201	Bracket - transistor	28480	00465-01201	1	
00465-66501	Board Etched Circuit Ass'y Power Supply - Amplifier	28480	00465-66501	1	
00465-90000	Manual, Operating and Service	28480	00465-90000	1	

> Option 01 only

See introduction to this section

APPENDIX

CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	
00000	U.S.A. Common	Any supplier of U.S.	07115	Corning Glass Works		24655	General Radio Co.	West Concord, Mass.	73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.	
00138	McCoy Electronics	Mount Holly Springs, Pa.	07126	Digitron Co.	Bradford, Pa.	25365	Gries Reproducer Corp.	New Rochelle, N.Y.	73445	Amperex Electronic Co. Div. of North American Phillips Co., Inc.	Hicksville, N.Y.	
00213	Sage Electronics Corp.	Rochester, N.Y.	07137	Transistor Electronics Corp.	Pasadena, Calif.	26452	Grobet File Co. of America, Inc.	Carlsbad, N.J.	73490	Beckman Helipot Corp.	So. Pasadena, Calif.	
00334	Huonital Co.	Colton, Calif.	07138	Westinghouse Electric Corp.	Minneapolis, Minn.	26892	Haniton Watch Co.	Lancaster, Pa.	73506	Bradley Semiconductor Corp.	Hanover, Conn.	
00335	Westrex Corp.	New York, N.Y.		Electron Tube Div.	Elmira, N.Y.	26890	Hewlett-Packard Co.	Palo Alto, Calif.	73559	Carling Electric, Inc.	Hartford, Conn.	
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.	07149	Filmohm Corp.	New York, N.Y.	31173	G.E. Receiving Tube Dept.	Owensboro, Ky.	73682	George K. Garrett Co., Inc.	Philadelphia, Pa.	
00656	Aerovox Corp.	New Bedford, Mass.	07233	Cinch-Graphik Co.	City of Industry, Calif.	35434	Lectrohinc Inc.	Chicago, Ill.	73734	Federal Screw Prod. Co.	Chicago, Ill.	
00779	Amp, Inc.	Harrisburg, Pa.	07261	Aveet Corp.	Los Angeles, Calif.	37942	P.R. Mallory & Co., Inc.	Indigoapolis, Ind.	73743	Fischer Special Mfg. Co.	Cincinnati, Ohio	
00781	Aircraft Radio Corp.	Boonton, N.J.	07263	Fairchild Semiconductor Corp.	Mountain View, Calif.	39543	Mechanical Industries Prod. Co.	Akron, Ohio	73793	The General Industries Co.	Elyria, Ohio	
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.	07322	Minnesota Rubber Co.	Minneapolis, Minn.	40920	Minature Precision Bearings, Inc.	Keene, N.H.	73846	Goshen Stamping & Tool Co.	Goshen, Ind.	
00853	Sangamo Electric Company, Ordil Division (Capacitors)	Marion, Ill.	07387	The Birtcher Corp.	Los Angeles, Calif.	42190	Mutel Co.	Chicago, Ill.	73898	JFD Electronics Corp.	Brooklyn, N.Y.	
00866	Gee Engineering Co.	Los Angeles, Calif.	07700	Technical Wire Products	Springfield, N.J.	43590	C.A. Karpes Co.	Englewood, Colo.	73905	Jennings Radio Mfg. Co.	San Jose, Calif.	
00891	Carl E. Holmes Corp.	Los Angeles, Calif.	07910	Continental Device Corp.	Hawthorne, Calif.	44655	Ohmite Mfg. Co.	Skokie, Ill.	74276	Signalite Inc.	Neptune, N.J.	
01121	Allen Bradley Co.	Milwaukee, Wis.	07933	Rheem Semiconductor Corp.	Mountain View, Calif.	47908	Polaroid Corp.	Cambridge, Mass.	74455	J.H. Wiers, and Sons	Winchester, Mass.	
01255	Littton Industries, Inc.	Beverly Hills, Calif.	07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.	48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.	74861	Industrial Condenser Corp.	Chicago, Ill.	
01281	TRW Semiconductors Inc.	Lawndale, Calif.	07980	Boonton Radio Corp.	Boonton, N.J.	49956	Raytheon Company	Lexington, Mass.	74888	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.	
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas	08145	U.S. Engineering Co.	Los Angeles, Calif.	52790	Rowan Controller Co.	Baltimore, Md.	74970	E.F. Johnson Co.	Waseca, Minn.	
01349	The Allis Mfg. Co.	Alliance, Ohio	08289	Blima, Delbert, Co.	Pomona, Calif.	52742	Ward Leonard Electric	Mt. Vernon, N.Y.	75042	International Resistance Co.	Philadelphia, Pa.	
01561	Chassi-Trak Corp.	Indianapolis, Ind.	08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada	52924	Shatford Mfg. Co.	Sefton, N.C.	75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.	
01589	Pacific Relays, Inc.	Van Nuys, Calif.				55026	Simpson Electric Co.	Erlau, N.Y.	75378	James Knight Co.	Sandwich, Ill.	
01930	Ametek Corp.	Rockford, Ill.	08671	Stoan Company	Burbank, Calif.	55933	Sonotone Corp.	No. Norwalk, Conn.	75382	Kurka Electric Corporation	Mt. Vernon, N.Y.	
01961	Pulse Engineering Co.	Santa Clara, Calif.	08678	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.	55938	Sorenson Co., Inc.	Tonawanda, N.Y.	75818	Lenz Electric Mfg. Co.	Chicago, Ill.	
02114	Ferroxcube Corp. of America	Saugerties, N.Y.	08792	CB5 Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.	56137	Spaulding Fibre Co., Inc.	North Adams, Mass.	75915	Littlefuse Inc.	Des Plaines, Ill.	
02286	Cole Mfg. Co.	Palo Alto, Calif.	08894	Met-Rain	Indianapolis, Ind.	56289	Sprague Electric Co.	St. Paul, Minn.	76005	Lord Mfg. Co.	Erie, Pa.	
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.	09026	Babcock Relays, Inc.	Costa Mesa, Calif.	59730	Thosas & Betts Co.	Elizabeth, N.J.	76210	C.W. Marquell	San Francisco, Calif.	
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.	09134	Texas Capacitor Co.	Houston, Texas	61775	Trippel Electrical Inc.	Bluffton, Ohio	76433	Midland Electronic Mfg. Corp.	Brooklyn, N.Y.	
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.	09230	Atmos Electronics	San Valley, Calif.		Westinghouse Air Brake Co.	Swissvale, Pa.	76437	James Milen Mfg. Co., Inc.	Malden, Mass.	
02777	Hopkins Engineering Co.	San Fernando, Calif.	09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada	62119	Universal Electric Co.	Ossosso, Mich.	76493	J.W. Miller Co.	Los Angeles, Calif.	
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.	09664	The Bristol Co.	Waterbury, Conn.	62743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.	76530	Monadnock Mills	San Leandro, Calif.	
03705	Apex Machine & Tool Co.	Dayton, Ohio	10214	General Transistor Western Corp.	Los Angeles, Calif.	64959	Western Electric Co., Inc.	New York, N.Y.	76545	Mueler Electric Co.	Cleveland, Ohio	
03797	Elektra Corp.	El Monte, Calif.	10411	Ti-Tal, Inc.	Berkeley, Calif.	65092	Western Ind. Div. of Daystrom, Inc.	Newark, N.J.	76584	Oak Manufacturing Co.	Crystal Lake, Ill.	
03877	Transiton Electronic Corp.	Wakefield, Mass.	10646	Catberndum Co.	Niagara Falls, N.Y.	66295	Whitell Manufacturing Co.	Chicago, Ill.	77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.	
03888	Pyramid Resistol Co.	Monroeville, N.J.	11236	CTS of Berne, Inc.	Berne, Ind.	70276	Aljen Mfg. Co.	Hartford, Conn.	77075	Phoenix Metal Co.	San Francisco, Calif.	
03954	Air Marine Motors, Inc.	Los Angeles, Calif.	11237	Chicago Telephone of California, Inc.		70309	Attili Control Co., Inc.	New York, N.Y.	77221	Phasitor Instrument and Electronic Co.	South Pasadena, Calif.	
04009	Arrow, Hart and Hegeman Elect. Co.	Harford, Conn.				70319	Allstate Screw Prod. Co., Inc.	Garden City, N.Y.	77250	Phoelt Mfg. Co.	Chicago, Ill.	
04013	Taurus Corp.	Lebanererville, N.J.	11312	Microwave Electronics Corp.	Palo Alto, Calif.	70495	Atlantic Indus Rubber Works, Inc.	Chicago, Ill.	77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.	
04062	Elmco Products Co.	New York, N.Y.	11534	Duncan Electronic, Inc.	Santa Ana, Calif.	70553	Amperite Co., Inc.	New York, N.Y.	77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.	
04222	Hi-Q Division of Aerovox	Mystic Beach, S.C.	11711	General Instrument Corporation Semiconductor Division	Newark, N.J.	70603	Belden Mfg. Co.	Cleveland, Ohio	77630	Radio Condenser Co.	Camden, N.J.	
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.	11717	Imperial Electronic, Inc.	Buena Park, Calif.	70799	Bird Electronic Corp.	New York, N.Y.	77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.	
04354	Precision Paper Tube Co.	Chicago, Ill.	11870	Philips-Dupont Handle Co.	Palo Alto, Calif.	71002	Binbach Radio Co.		77784	Resistance Products Co.	Harrisburg, Pa.	
04404	Dynac Division of Hewlett-Packard Co.	Palo Alto, Calif.	12136	Philips-Dupont Handle Co.	Caedon, N.J.	71041	Bosch Gear Works Div. of Murray Co. of Texas	Quincy, Mass.	77959	Rubbercraft Corp. of Calif.	Torrance, Calif.	
04651	Sylvania Electric Prods., Inc., Electronic Tube Div.	Mountain View, Calif.	12697	Clarostat Mfg. Co.	Dover, N.H.	71218	Bud Radio Inc.	Cleveland, Ohio	78189	Shakespear Division of Illinois Tool Works	Elgin, Ill.	
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona	12859	Nippon Electric Co., Ltd.	Tokyo, Japan	71265	Camloc Fastener Corp.	Parmaus, N.J.				
05096	Twentyfirst Century Plastics, Inc.	Los Angeles, Calif.	12930	Delta Semiconductor Inc.	Newport Beach, Calif.	71313	Allen D. Cardwell Electronic Prod. Co.	Ballas, Texas	78233	Signal Indicator Corp.	New York, N.Y.	
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.	13336	Telefunken (G.M.B.H.)	Hannover, Germany	71400	Bussmann Fuse Div. of McGraw-Edison Co.	Plainville, Conn.	78296	Studhers-Davis Inc.	Pitman, N.J.	
05347	Ultratec, Inc.	Sun Mate, Calif.	13935	Midland Mfg. Co.	Kansas City, Kansas	71436	Chicago Condenser Corp.	St. Louis, Mo.	78452	Thompson-Bremer & Co.	Chicago, Ill.	
05593	Ilmtronics Engineering Co.	Sunnyvale, Calif.	14039	Sem-Tech	Newbury Park, Calif.	71450	CITS Corp.	Elkhart, Ind.	78471	Tiltley Mfg. Co.	San Francisco, Calif.	
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio	14193	Carif. Resistor Corp.	Santa Monica, Calif.	71468	Connan Electric Co.	Los Angeles, Calif.	78488	Stackpole Carbon Co.	St. Marys, Pa.	
05624	Barber Colman Co.	Rockford, Ill.	14298	American Components, Inc.	Conshohocken, Pa.	71471	Clemco Engineering Co.	Burbank, Calif.	78493	Standard Thomson Corp.	Waltham, Mass.	
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.	14655	Comell Debilizer Elec. Corp.	So. Plainfield, N.J.	71482	C.P. Clare & Co.	Chicago, Ill.	78553	Tianerma Products, Inc.	Cleveland, Ohio	
05729	Westinghouse Electric Corp., Telecommunications Corp., Metric Csp. Division	Brooklyn, N.Y.	14950	Williams Mfg. Co.	San Jose, Calif.	71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.	78590	Transformer Engineers	Pasadena, Calif.	
05783	Stewart Engineering Co.	Santa Cruz, Calif.	17019	Thermonetics Inc.	N. Hollywood, Calif.	71616	Commercial Plastics Co.	Chicago, Ill.	78947	Uclite Co.	Newtownville, Mass.	
05820	Wakeland Engineering Inc.	Wakefield, Mass.	17474	Tianex Company	Mountain View, Calif.	71760	The Cornish Wire Co.	New York, N.Y.	79142	Veder Root, Inc.	Hartford, Conn.	
06024	The Bassick Co.	Bridgeport, Conn.	18485	Radio Industries	Des Plaines, Ill.	71744	Chicago Miniature Lamp Works	Chicago, Ill.	79251	Wenco Mfg. Co.	Chicago, Ill.	
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.	18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.	71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.	79272	Continental-Witt Electronics Corp.	Philadelphia, Pa.	
06402	E.T.A. Products Co. of America	Chicago, Ill.	18783	E.I. DuPont and Co., Inc.	Wilmington, Del.	71785	Cinch Mfg. Corp.	Chicago, Ill.	79693	Zierick Mfg. Corp.	New Rochelle, N.Y.	
06475	Western Devices, Inc.	Inglewood, Calif.	21226	Executive, Inc.	New York, N.Y.	71984	Dow Corning Corp.	Midland, Mich.	80031	Meaco Division of Sessions Clock Co.	Morristown, N.J.	
06540	Amaton Electronic	Hardware Co. Inc.	21226	Executive, Inc.	New York, N.Y.	72092	Eltel-McCullough, Inc.	San Bruno, Calif.	80120	Schmitz Alloy Products	Elizabeth, N.J.	
06555	Bedeer Electrical Instrument Co., Inc.	Penhook, N.H.	21520	Fansleel Metallurgical Corp.	No. Chicago, Ill.	72136	Electro Motive Mfg. Co., Inc.	Newark, N.J.	80130	Times Facsimile Corp.	New York, N.Y.	
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona	21335	The Fafnir Bearing Co.	New Britain, Conn.	72172	General Instrument Corp., Semiconductor Div.	Providence, R.I.	80131	Electronic Industries Association, Any brand tube meeting EIA standards	Washington, D.C.	
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.	21954	Fed. Telephone and Radio Corp.	Clifton, N.J.	72178	Girard-Hopkins	Chicago, Ill.	80207	Urimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.	
07088	Kelvin Electric Co.	Van Nuys, Calif.	24446	General Electric Co.	Schenectady, N.Y.	72175	Drake Mfg. Co.	Philadelphia, Pa.	80223	United Transformer Corp.	New York, N.Y.	
			24455	G.E., Lamp Division Nela Park, Cleveland, Ohio		72292	Gudeman Co.	Chicago, Ill.	80248	Oxford Electric Corp.	Chicago, Ill.	
						72659	General Instrument Corp.	Los Angeles, Calif.	80294	Bourns Laboratories, Inc.	Riverside, Calif.	
							Newark, N.J.	80411	Acro Div. of Robertshaw	Fulton Controls Co.		
							Oakland, Calif.	80486	Defair Products Inc.	Columbus 16, Ohio		
							Chicago, Ill.	80509	Any Adhesive Label Corp.	Defiance, Ohio		
							Brooklyn, N.Y.	80583	Hammerland Co., Inc.	Monrovia, Calif.		
							Keasbey, N.J.	80640	Stevens, Arnold, Co., Inc.	New York, N.Y.		
							Los Angeles, Calif.	81030	International Instruments, Inc.	Boston, Mass.		
							Erie, Pa.			New Haven, Conn.		
							Princeton, Ind.			LaGrange, Ill.		
							Chicago, Ill.			Venice, Calif.		
							73061	Hansen Mfg. Co., Inc.		81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
							73076	Harpel Co.				
							73138	Heipol Div. of Beckman Instruments, Inc.	Fullerton, Calif.			

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
81349	Military Specification	.....	85474	R. M. Bracanotte & Co.	San Francisco, Calif.	53829	G. V. Controls	Livingston, N. J.	98220	Francis L. Mosley	Pasadena, Calif.
81415	Wilke Products, Inc.	Cleveland, Ohio	85660	Koiled Kords, Inc.	New Haven, Conn.	93983	Insuline-Van Norman Ind., Inc.	.....	96278	Microdot, Inc.	So. Pasadena, Calif.
81453	Raytheon Mfg. Co., Industrial Components Div., Indstr. Tube Operations	Newton, Mass.	85911	Seamless Rubber Co.	Chicago, Ill.	93983	Electronic Division	Manchester, N.H.	96291	Sealectro Corp.	Mamaroneck, N.Y.
81483	International Rectifier Corp.	El Segundo, Calif.	86197	Clifton Precision Products	Clifton Heights, Pa.	94137	General Cable Corp.	Bayonne, N.J.	98405	Card Corp.	Redwood City, Calif.
81541	The Alipax Products Co.	Cambridge, Mass.	85579	Precision Rubber Products Corp.	Dayton, Ohio	94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.	97371	General Mills	Minneapolis, Minn.
81860	Barry Controls, Inc.	Watertown, Mass.	86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.	94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.	98821	North Hills Electric Co.	Mineola, N.Y.
82042	Carter Parts Co.	Skokie, Ill.	87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.	94148	Scientific Radio Products, Inc.	.....	99295	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
82142	Jeffers Electronics Division of Speed Carbon Co.	Du Bois, Pa.	87473	Western Fibrous Glass Products Co.	San Francisco, Calif.	94154	Tung-Sol Electric, Inc.	Loveland, Colo.	98978	International Electronic Research Corp.	Burbank, Calif.
82170	Alten B. Dumont Labs, Inc.	Clifton, N.J.	87664	Van Waters & Rogers Inc.	Seattle, Wash.	94197	Curtiss-Wright Corp.	Newark, N.J.	99109	Columbia Technical Corp.	New York, N.Y.
82209	Maguire Industries, Inc.	Greenwich, Conn.	87930	Tower Mfg. Corp.	Providence, R. I.	94222	Electronics Div.	East Paterson, N.J.	99313	Varian Associates	Palo Alto, Calif.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporia, Pa.	88140	Cutter-Hammer, Inc.	Lincoln, Ill.	94310	Tu-Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.	99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
82376	Aston Co.	East Newark, N.J.	88220	Gould-National Batteries, Inc.	St. Paul, Minn.	94330	Wire Cloth Products Inc.	Chicago, Ill.	99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
82389	Switchcraft, Inc.	Chicago, Ill.	88698	General Mills, Inc.	Buffalo, N.Y.	94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.	99800	Delevan Electronics Corp.	East Aurora, N.Y.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc.	Spencer Prod.	89231	Graybar Electric Co.	Oakland, Calif.	95203	Philbrick Researchers, Inc.	Boston, Mass.	99848	Wilco Corporation	Indianapolis, Ind.
		Attleboro, Mass.	89462	Waldes Kohinoor, Inc.	Cambridge, Mass.	95236	Allis Products Corp.	Miami, Fla.	99934	Reedbrand, Inc.	Boston, Mass.
			89473	General Electric Distributing Corp.	Schenectady, N.Y.	95238	Continental Connector Corp.	Woodside, N.Y.	99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
82866	Research Products Corp.	Madison, Wis.	89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.	95263	Leecraft Mfg. Co., Inc.	New York, N.Y.	99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.	89665	United Transformer Co.	Chicago, Ill.	95264	Lerco Electronics, Inc.	Burbank, Calif.			
82893	Vector Electric Co.	Glendale, Calif.	90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.	95265	National Coil Co.	Sheridan, Wyo.			
83053	Western Washer Mfg. Co.	Los Angeles, Calif.	90870	Beating Engineering Co.	San Francisco, Calif.	95275	Vitramon, Inc.	Bridgewater, Conn.			
83058	Carr Fastener Co.	Cambridge, Mass.	91260	Connor Spring Mfg. Co.	San Francisco, Calif.	95345	Cordis Corp.	Bloomfield, N.J.			
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.	91345	Miller Dial & Nameplate Co.	El Monte, Calif.	95354	Methode Mfg. Co.	Chicago, Ill.			
83125	Pyramid Electric Co.	Darlington, S.C.	91418	Radio Materials Co.	Chicago, Ill.	95712	Dage Electric Co., Inc.	Flaeklin, Ind.			
83148	Electro Cords Co.	Los Angeles, Calif.	91508	Augat Brothers', Inc.	Attleboro, Mass.	95987	Weckesser Co.	Chicago, Ill.			
83186	Victory Engineering Corp.	Springfield, N.J.	91537	Date Electronics, Inc.	Columbus, Nebr.	96067	Huggins Laboratories	Sunnyvale, Calif.			
83198	Bendix Corp., Red Bank Div.	Red Bank, N.J.	91662	Etco Corp.	Philadelphia, Pa.	96095	Hi-Q Division of Aerovox	Olean, N.Y.			
83315	Hubbell Corp.	Mundelein, Ill.	91737	Gemar Mfg. Co., Inc.	Wakefield, Mass.	96256	Thordason-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.			
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.	91827	K F Development Co.	Redwood City, Calif.	96296	Solar Manufacturing Co.	Los Angeles, Calif.			
83365	Central Screw Co.	Chicago, Ill.	91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.	96330	Carilon Screw Co.	Chicago, Ill.			
83501	Gavitt Wire and Cable Co., Div. of Ametco Corp.	Brockfield, Mass.	91961	Nahm-Bros. Spring Co.	Oakland, Calif.	96341	Microwave Associates, Inc.	Burlington, Mass.			
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.	92150	Tru-Connector Corp.	Pesbody, Mass.	96591	Excel Transformer Co.	Oakland, Calif.			
83740	Eveready Battery	New York, N.Y.	92199	Universal Metal Prod., Inc.	Bassett Puerto, Calif.	97464	Industrial Retaining Ring Co.	Irvington, N.J.			
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.	92367	Eiget Optical Co., Inc.	Rochester, N.Y.	97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.			
83821	Lord Scrogs Co.	Festus, Mo.	92607	Tiastyle Insulated Wire Co.	Tarrytown, N.Y.	97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.			
84171	Arco Electronics, Inc.	New York, N.Y.	93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.	97979	Reon Resistor Corp.	Yonkers, N.Y.			
84396	A. J. Gleason Co., Inc.	San Francisco, Calif.	93369	Robbins and Myers, Inc.	New York, N.Y.	98141	Axel Brothers Inc.	Jamaica, N.Y.			
84411	Good All Electric Mfg. Co.	Ogallala, Neb.	93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio	98159	Rubber Tech, Inc.	Cardena, Calif.			
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.	93788	Howard J. Smith Inc.	Port Monmouth, N.J.						
85454	Boonton Molding Company	Brenton, N.J.									
85471	A. B. Boyd Co.	San Francisco, Calif.									

SALES AND SERVICE OFFICES IN THE U.S. AND CANADA

ALABAMA
 Huntsville, 35801
 Hewlett-Packard
 Southern Sales Division
 Holiday Office Ctr., Suite 18
 (205) 881-4591
 TWX: 510-579-2204

ARIZONA
 Scottsdale, 85251
 Hewlett-Packard
 Neely Sales Division
 3009 N. Scottsdale Rd.
 (602) 945-7601
 TWX: 602-949-0111
 Tucson, 85716
 Hewlett-Packard
 Neely Sales Division
 232 So. Tucson Blvd.
 (602) 623-2564
 TWX: 602-792-2759

CALIFORNIA
 Los Angeles Area
 Hewlett-Packard
 Neely Sales Division
 3939 Lankershim Blvd.
 North Hollywood 91604
 (213) 877-1282 and 766-3811
 TWX: 910-499-2170

Sacramento, 95821
 Hewlett-Packard
 Neely Sales Division
 2591 Carlsbad Ave.
 (916) 482-1463
 TWX: 916-444-8683

San Diego, 92106
 Hewlett-Packard
 Neely Sales Division
 1055 Shafter Street
 (714) 223-8103
 TWX: 714-276-4263

San Francisco Area
 Hewlett-Packard
 Neely Sales Division
 501 Laurel Street
 San Carlos 94071
 (415) 591-7661
 TWX: 910-376-4390

COLORADO
 Englewood, 80110
 Hewlett-Packard
 Lahana Sales Division
 7965 East Prentice
 (303) 771-3455
 TWX: 303-771-3056

CONNECTICUT
 Middletown, 06458
 Hewlett-Packard
 Yewell Sales Division
 589 Saybrook Rd.
 (203) 346-6611
 TWX: 203-346-7433

FLORIDA
 Miami, 33125
 Hewlett-Packard
 Florida Sales Division
 2907 Northwest 7th St.
 (305) 635-6461
 Orlando, 32803
 Hewlett-Packard
 Florida Sales Division
 621 Commonwealth Ave.
 (305) 425-5541
 TWX: 305-275-1234

St. Petersburg, 33708
 Hewlett-Packard
 Florida Sales Division
 410-150th Ave., Madeira Beach
 (813) 391-0211
 TWX: 813-391-0666

GEORGIA
 Atlanta, 30305
 Hewlett-Packard
 Southern Sales Division
 3110 Maple Drive, N. E.
 (404) 233-1141
 TWX: 810-751-3283

ILLINOIS
 Chicago, 60645
 Hewlett-Packard
 Crossley Sales Division
 2501 West Peterson Ave.
 (312) 275-1600
 TWX: 910-221-0277

INDIANA
 Indianapolis, 46205
 Hewlett-Packard
 Crossley Sales Division
 3919 Meadows Dr.
 (317) 546-4891
 TWX: 317-635-4300

KENTUCKY
 Louisville, 40218
 Hewlett-Packard
 Southern Sales Division
 Suite 4, 3411 Bardstown Rd.
 (502) 459-4140
 TWX: 810-535-3128

MARYLAND
 Baltimore, 21207
 Hewlett-Packard
 Horman Sales Division
 6660 Security Blvd.
 (301) 944-5400
 Washington, D. C. Area
 Hewlett-Packard
 Horman Sales Division
 941 Rollins Avenue
 Rockville 20852
 (301) 427-7560
 TWX: 710-828-9684

MASSACHUSETTS
 Boston Area
 Hewlett-Packard
 Yewell Sales Division
 Middlesex Turnpike
 Burlington 01804
 (617) 272-9000
 TWX: 710-332-0382

MICHIGAN
 Detroit, 48235
 Hewlett-Packard
 Crossley Sales Division
 14425 West Eight Mile Road
 (313) 342-5700
 TWX: 313-342-0702

MINNESOTA
 St. Paul, 55114
 Hewlett-Packard
 Crossley Sales Division
 842 Raymond Avenue
 (612) 646-7881
 TWX: 612-551-0055

MISSOURI
 Kansas City, 64131
 Harris-Hanson Company
 7916 Paseo Street
 (816) 444-9494
 TWX: 816-556-2423
 St. Louis, 63144
 Harris-Hanson Company
 2814 South Brentwood Blvd.
 (314) 647-4350
 TWX: 314-962-3933

NEW JERSEY
 Asbury Park Area
 Hewlett-Packard
 Robinson Sales Division
 Shrewsbury
 (201) 747-1060

Englewood, 07631
 Hewlett-Packard
 RMC Sales Division
 391 Grand Avenue
 (201) 567-3933

NEW MEXICO
 Albuquerque, 87108
 Hewlett-Packard
 Neely Sales Division
 6501 Lomas Blvd., N. E.
 (505) 255-5586
 TWX: 505-243-8314

Las Cruces, 88001
 Hewlett-Packard
 Neely Sales Division
 114 S. Water Street
 (505) 526-2486
 TWX: 505-524-2671

NEW YORK
 New York, 10021
 Hewlett-Packard
 RMC Sales Division
 236 East 75th Street
 (212) 879-2023
 TWX: 710-581-4376
 Rochester, 14625
 Hewlett-Packard
 Syracuse Sales Division
 800 Linden Avenue
 (716) 381-4120
 TWX: 716-221-1514

Poughkeepsie, 12601
 Hewlett-Packard
 Syracuse Sales Division
 82 Washington St.
 (914) 454-7330
 TWX: 914-452-7425
 Syracuse, 13211
 Hewlett-Packard
 Syracuse Sales Division
 Pickard Bldg., E. Molloy Rd.
 (315) 454-2486
 TWX: 315-477-1375

NORTH CAROLINA
 High Point, 27262
 Hewlett-Packard
 Southern Sales Division
 1923 N. Main Street
 (919) 882-6873
 TWX: 510-926-1516

OHIO
 Cleveland, 44129
 Hewlett-Packard
 Crossley Sales Division
 5579 Pearl Road
 (216) 884-9209
 TWX: 216-888-0715
 Dayton, 45409
 Hewlett-Packard
 Crossley Sales Division
 1250 W. Dorothy Lane
 (513) 299-3594
 TWX: 513-944-0090

PENNSYLVANIA
 Camp Hill
 Hewlett-Packard
 Robinson Sales Division
 (717) 737-6791

Philadelphia Area
 Hewlett-Packard
 Robinson Sales Division
 144 Elizabeth Street
 West Conshohocken 19428
 (215) 248-1600 and 828-6200
 TWX: 215-828-3847

Pittsburgh Area
 Hewlett-Packard
 Crossley Sales Division
 2545 Moss Side Blvd.
 Monroeville 15146
 (412) 271-5227
 TWX: 710-797-3650

TEXAS
 Dallas, 75209
 Hewlett-Packard
 Southwest Sales Division
 P.O. Box 7166, 3605 Inwood Rd.
 (214) 357-1881 and 332-6667
 TWX: 910-861-4081

Houston, 77027
 Hewlett-Packard
 Southwest Sales Division
 P.O. Box 22813, 4242 Richmond Ave.
 (713) 667-2407
 TWX: 713-571-1353

UTAH
 Salt Lake City, 84115
 Hewlett-Packard
 Lahana Sales Division
 1482 Major St.
 (801) 486-8166
 TWX: 801-521-2604

VIRGINIA
 Richmond, 23230
 Hewlett-Packard
 Southern Sales Division
 2112 Spencer Road
 (703) 282-5451
 TWX: 703-282-9986

WASHINGTON
 Seattle Area
 Hewlett-Packard
 Neely Sales Division
 11656 N. E. 8th St.
 Bellevue 98004
 (206) GL4-3971
 TWX: 910-443-2303

CANADA
 Montreal, Quebec
 Hewlett-Packard (Canada) Ltd.
 8270 Mayrand Street
 (514) 735-2273
 TWX: 610-421-3484
 Ottawa, Ontario
 Hewlett-Packard (Canada) Ltd.
 1762 Carling Avenue
 (613) 722-4223
 TWX: 610-562-1952

Toronto, Ontario
 Hewlett-Packard (Canada) Ltd.
 1415 Lawrence Avenue, West
 (416) 249-9196
 TWX: 610-492-2382

HEWLETT  **PACKARD**

INTERNATIONAL SALES AND SERVICE OFFICES

ARGENTINA

Mauricio A. Saurez
Telecommunicaciones
Carlos Calvo 224, Buenos Aires
Tel: 30-6312

AUSTRALIA

Sample Electronics (Vic.) Pty. Ltd.
9-11 Cremorne Street
Richmond E. 1, Victoria
Tel: 42-4757 (3 lines)
Sample Electronics (N.S.W.) Pty. Ltd.
4 Grose Street, Glebe, Sydney
New South Wales
Tel: 69-6338 (6 lines)

AUSTRIA

Unitabor G.m.b.H.
Rummelhartgasse 6/3
Vienna
Tel: 426.181

BELGIUM

Hewlett-Packard Benelux S.A.
20-24 Rue de l'Hopital, Brussels
Tel: 11.22.20

BRAZIL

Ciental Importacao E Comercio Ltda.
Rua Cons. Crispiniano, 69, 8.º And.,
Conj. 81, Sao Paulo
Tel: 32-4332

CANADA

Hewlett-Packard (Canada) Ltd.
8270 Mayrand Street
Montreal, Quebec
(514) 735-2273
Hewlett-Packard (Canada) Ltd.
1762 Carling Avenue
Ottawa, Ontario
(613) 722-8162
Hewlett-Packard (Canada) Ltd.
1415 Lawrence Avenue W.
Toronto, Ontario
(416) 249-9196

CHILE

Hector Calcagni
Casilla 13942
Santiago
Tel: 6.42.26

DENMARK

Tage Olsen A/S
Ronneegade 1
Copenhagen Ø
Tel: 29.48.00

FINLAND

INTO O/Y
P. O. Box 153
Meritullinkatu 11, Helsinki
Tel: 66.39.09 and 35.125

FRANCE

Hewlett-Packard France
150 Boulevard Massena
Paris 13e
Tel: 707.97.19

GERMANY

Hewlett-Packard V.m.b.H.
Steindamm 35, Hamburg
Tel: 24.05.51
Hewlett-Packard V.m.b.H.
Kurhessenstrasse 95
Frankfurt am Main
Tel: 52.00.36

Hewlett-Packard V.m.b.H.

Regnifriedstrasse 13
Munich 9
Tel: 49.51.21/22
Hewlett-Packard Vm.b.H.
Technisches Büro
Herrenbergerstrasse 110
703 Böblingen, Württemberg
Tel: 6971

GREECE

K. Karayannis
Klaftmonos Square, Athens 124
Tel: 230.301 (5 lines)

INDIA

The Scientific Instrument Company, Ltd.
6, Tej Bahadur Sapru Road, Allahabad 1
Tel: 2451

The Scientific Instrument Company, Ltd.
240, Dr. Dadabhai Naoroji Road,
Bombay 1
Tel: 26-2642

The Scientific Instrument Company, Ltd.
11, Esplanade East, Calcutta 1
Tel: 23-4129

The Scientific Instrument Company, Ltd.
30, Mount Road, Madras 2
Tel: 86339

The Scientific Instrument Company, Ltd.
B-7, Ajmeri Gate Extn., New Delhi 1
Tel: 271053

IRAN

Telecom Ltd.
P. O. Box 1812, Tehran
Tel: 43850, 48111

ISRAEL

Electronics & Engineering Ltd.
16 Kremenski St., Tel Aviv
Tel: 35021 (3 lines)

ITALY

Hewlett-Packard Italiana S.p.A.
Viale Lunigiana 46, Milan
Tel: 69.15.84/5/6
Hewlett-Packard Italiana S.p.A.
Piazza Marconi, 25
Roma-Eur
Tel: 59.25.44/5

JAPAN

Yokogawa-Hewlett-Packard Ltd.
2270 Ishikawa-cho
Hachioji, Tokyo
Tel: Hachioji 0426-3-1231 (19 lines)

Yokogawa-Hewlett-Packard Ltd.
No. 3, 6-chome, Aoyama-Kitamachi
Akasaka, Minato-ku, Tokyo
Tel: 403-0073, 403-0074, 403-0075

Yokogawa-Hewlett-Packard Ltd.
No. 8, Umeda, Kita-ku, Osaka City
Tel: 361-3084, 341-2095

Yokogawa-Hewlett-Packard Ltd.
No. 4, 3-chome, Himeikedori,
Chigusa-ku, Nagoya City
Tel: 75-8545

KOREA

American Trading Company, Korea, Ltd.
112-35 Sokong-Dong
Seoul P. O. Box 1103
Seoul
Tel: 3-7049, 3-7613

NETHERLANDS

Hewlett-Packard Benelux N.V.
23 Burg Roelstraat, Amsterdam W.
Tel: (020) 13.28.98 and 13.54.99

NEW ZEALAND

Sample Electronics (N. Z.) Ltd.
8 Matipo Street
Onehunga S. E. 5, Auckland
Tel: 565-361

NORWAY

Morgenstjerne & Co. A/S
Ingeniørfirma
6 Wessels Gate, Oslo
Tel: 20 16 35

PORTUGAL

Telectra
Rua Rodrigo da Fonseca 103
P. O. Box 2531
Lisbon 1
Tel: 68 60 72 and 68 60 73 and 68 60 74

PUERTO RICO & VIRGIN ISLANDS

San Juan Electronics, Inc.
150 Ponce de Leon, Stop 3
P. O. Box 5167
Pta. de Tierra Sta., San Juan 00906
Tel: 722-3342, 724-4406

SPAIN

ATAIO, Ingenieros
A. Aguilera, No. 8, Madrid 15
Tel: 223.27.42, 223.41.71, and 224.84.97

SOUTH AFRICA

F. H. Flanter & Co. (Pty.), Ltd.
Rosella House
Buitengracht Street, Cape Town
Tel: 3-3817

SWEDEN

H-P Instrument AB
Centralvagen 28, Solna Centrum
Tel: 08-83.08.30 and 10-83.08.30

SWITZERLAND

Max Pual Frey
Wankdorfeldstrasse 66, Bern
Tel: (031) 42.00.78

TAIWAN (FORMOSA)

Hwa Sheng Electronic Co., Ltd.
21 Nanking West Road, Taipei
Tel: 4-6076, 4-5936

TURKEY

TELEKOM Engineering Bureau
P.O. Box 376—Galata, Istanbul
Tel: 49.40.40

UNITED KINGDOM

Hewlett-Packard Ltd.
Dallas Road
Bedford, England
Tel: Bedford 68052

VENEZUELA

Citec, C. A.
Edif. Arisan-Of #4
Avda. Francisco de Miranda-Chacaito
Apartado del Este 10.837, Caracas
Tel: 71.88.05

YUGOSLAVIA

Belram S.A.
83 Av. des Mimosas
Brussels 15, Belgium
Tel: 35.29.58

For Sales and Service Assistance in Areas Not Listed Contact:

IN EUROPE

Hewlett-Packard, S. A.
54 Route des Acacias
Geneva, Switzerland
Telephone: (022) 42.81.50
Telex: 2.24.86
Cable: HEWPACKSA

IN LATIN AMERICA

Hewlett-Packard Inter-Americas
1501 Page Mill Road
Palo Alto, California 94304, U.S.A.
Telephone: (415) 326-7000
TWX: 910-373-1267
Telex: 033811 Cable: HEWPACK

ELSEWHERE

Hewlett-Packard
International Marketing Department
1501 Page Mill Road
Palo Alto, California 94304, U.S.A.
Telephone: (415) 326-7000
TWX: 910-373-1267
Telex: 033811 Cable: HEWPACK